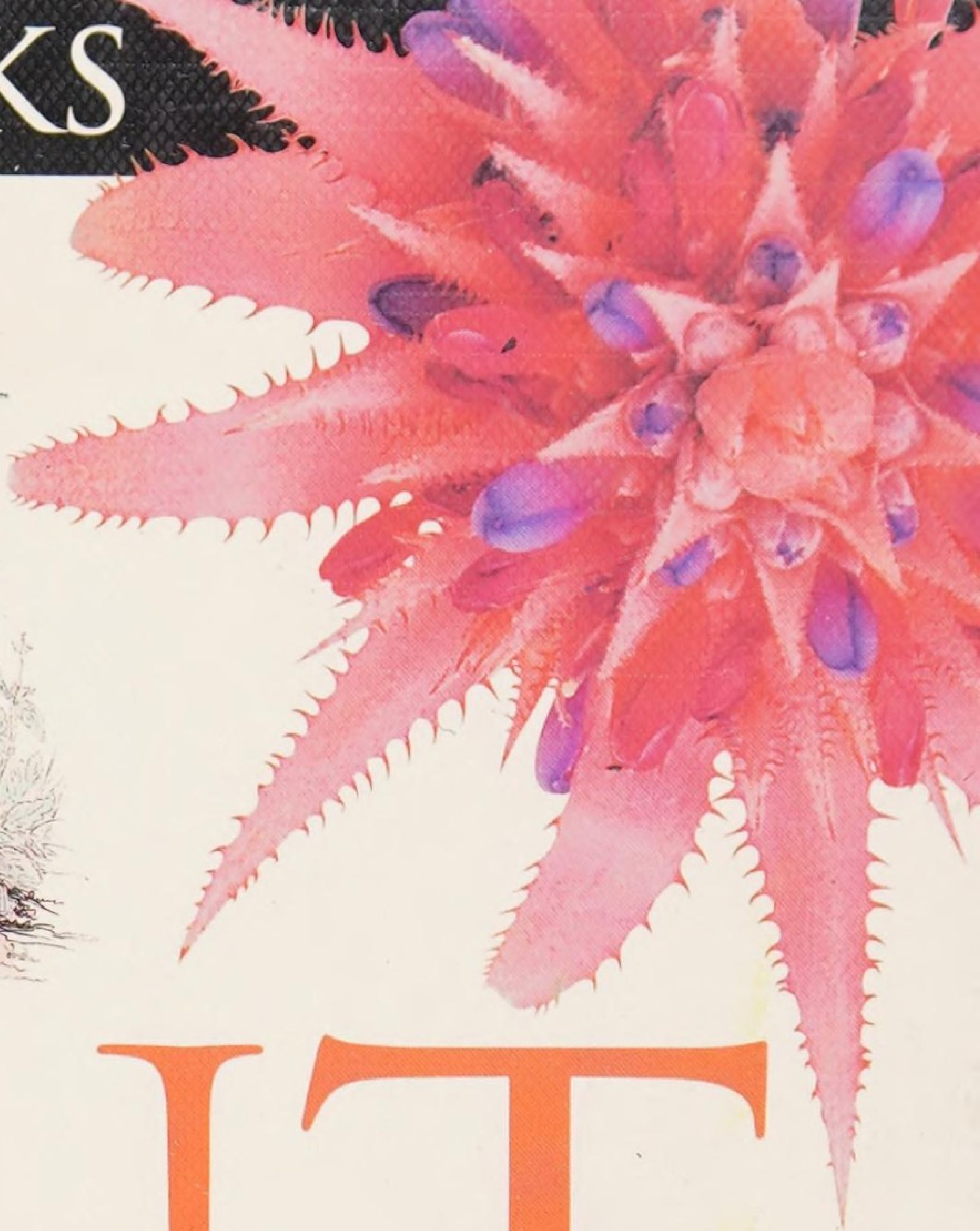
DK EYEWITNESS BOOKS



PLANT

Discover the fascinating world of plants – from flowers and fruit to plants that sting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BATTLE
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DANCE
DESERT
DINOSAUR
DOG
EAGLE & BIRDS OF PREY
EARLY HUMANS
EARTH
ECOLOGY
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FIRST LADIES
FISH
FLAG
FLYING MACHINE
FOOTBALL
FORCE & MOTION
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GORILLA, MONKEY & APE
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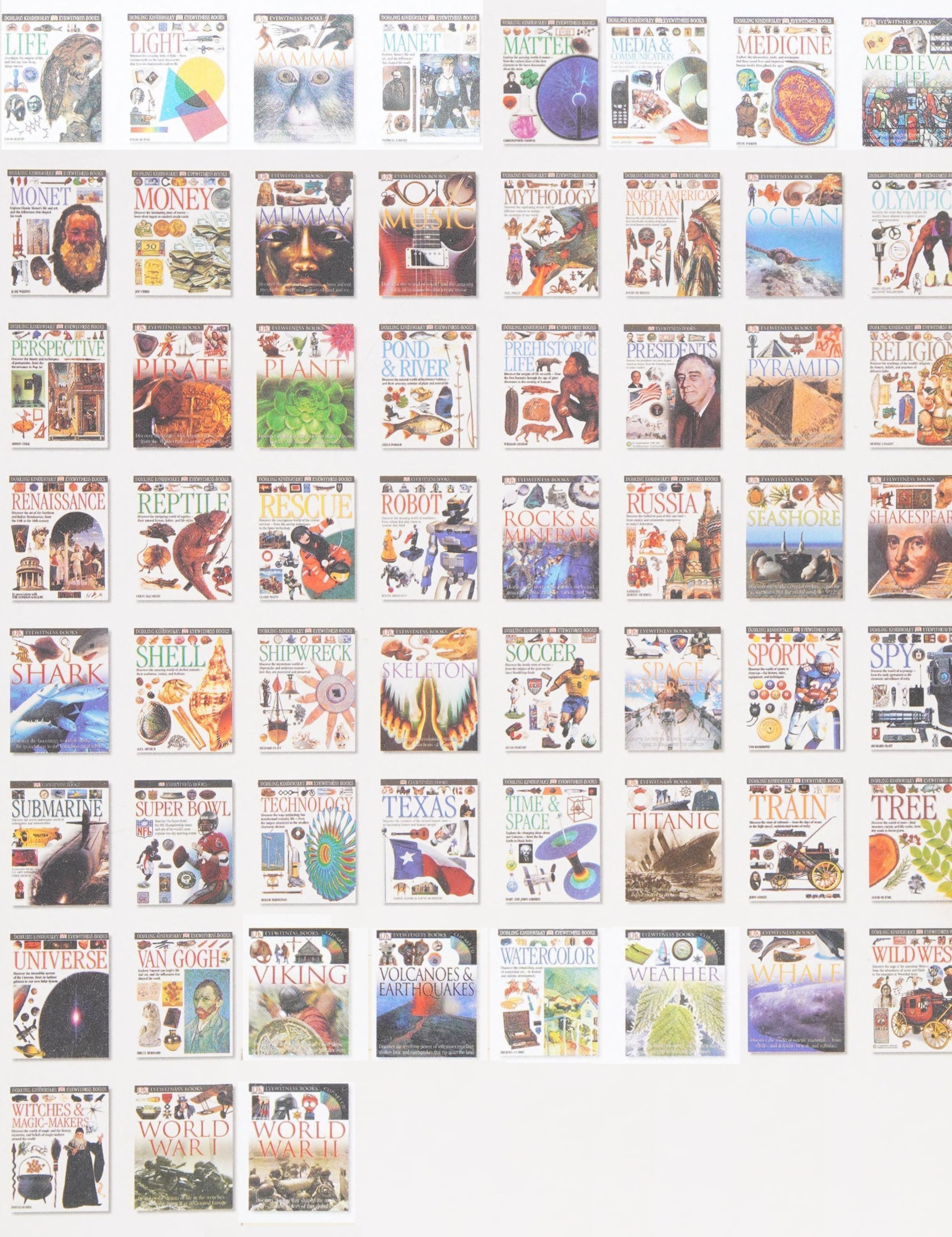
KNIGHT
LEONARDO & HIS TIMES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WORLD WAR I
WORLD WAR II

Eyewitness

PLANT


Blackberries
Red ginseng root
Radish
Gerbera flower
Moss on decaying wood
Peppers
Ornamental dried corn
Ribwort plantain seed heads
Opium poppy seed heads
Redshank flowers

Eyewitness
PLANT

Delphinium flowers

Garden pansies

Written by
DAVID BURNIE

Garden yarrow flower head

Columbine seed heads

Aster

Feverfew flowers

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Common sorrel

Ripe fig cut in half

Poppy seed head

Eucalyptus leaves

Field scabious

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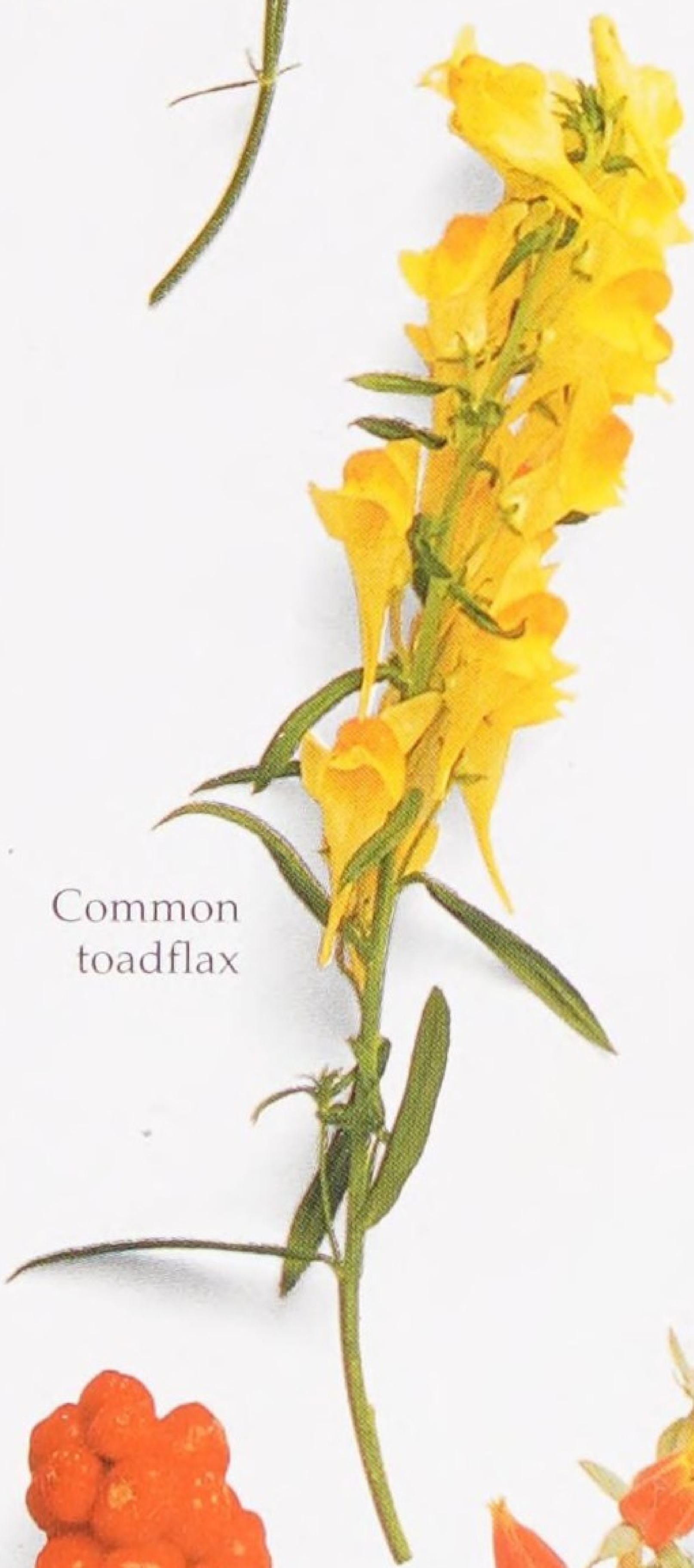
Creeping crowfoot

Cow vetch

Yarrow leaf



Common toadflax

Oxeye daisy

Cuckoo-pint

Flower of blue echeveria

Bull thistle

Contents

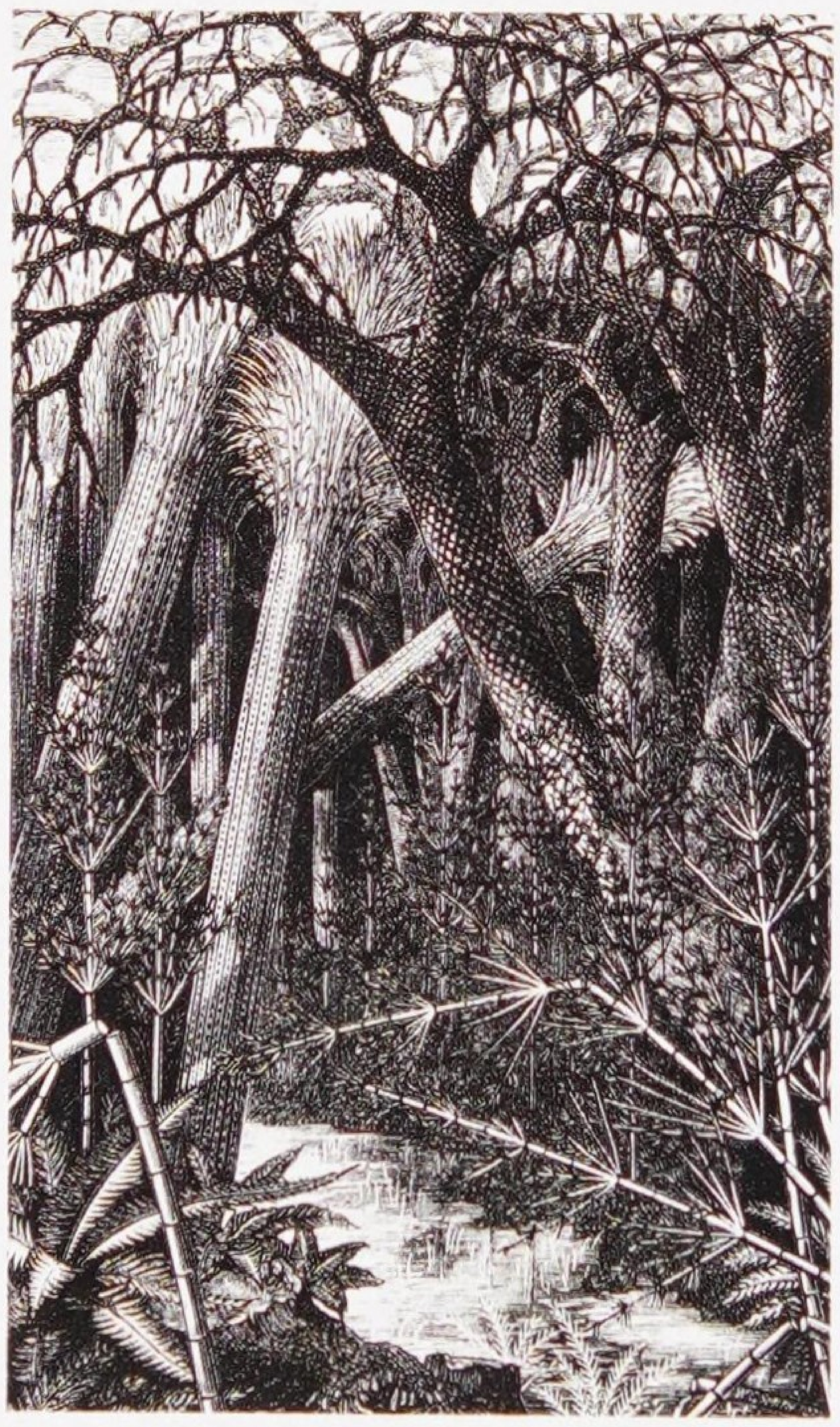
What is a plant?

Plants are the key to life on Earth. Without them many other living organisms would soon disappear. This is because higher life forms depend on plants, either directly or indirectly, for their food. Most plants, however, are able to make their own food using sunlight. All plants fall into two basic categories. Flowering plants, which this book looks at in some detail, produce true flowers. The nonflowering plants include "primitive" plants, such as mosses, ferns, horsetails, and liverworts, and the gymnosperms, a group of plants which includes the conifers, like the giant sequoias, shown opposite. There are about a quarter of a million species of flowering plants in the world today, and they grow almost everywhere from snowy mountain slopes to arid deserts. This book tells their story.

THIS IS NOT A PLANT
It is often difficult to tell simple plants and animals apart. This plantlike organism is a hydrozoan and lives in the sea. Its "branches" are formed by tiny animals called polyps, which have tentacles to trap particles of food.

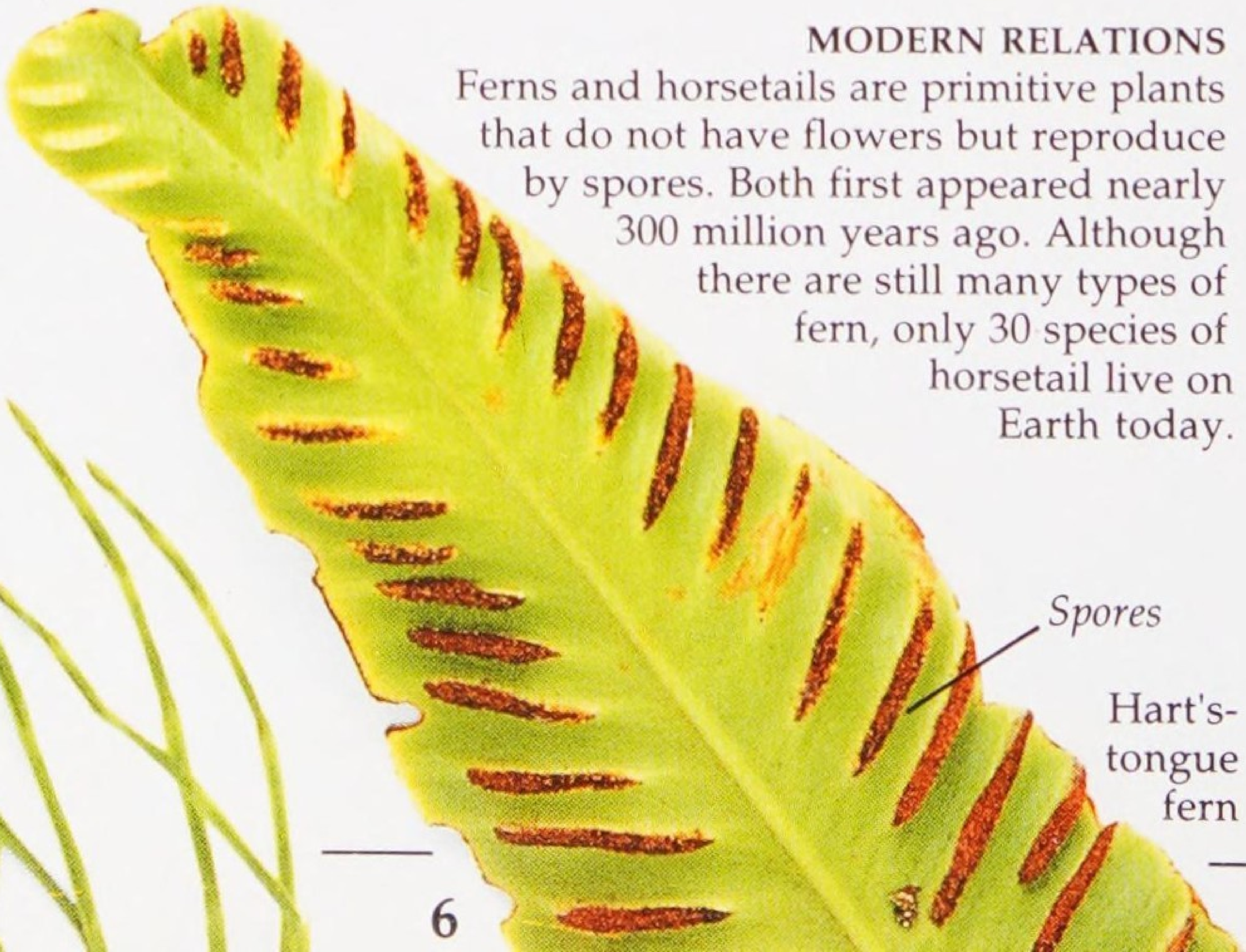
Lichens growing on limestone rock

THIS IS A PLANT
A lichen is made up of two different organisms: a tiny nonflowering plant called an alga, and a fungus. The algal cells live among the tiny threads formed by the fungus and supply the fungus with food, which they make using sunlight (pp. 14-15). The fungus cannot make its own food and would die without the alga. Lichens grow very slowly and are extremely long-lived.



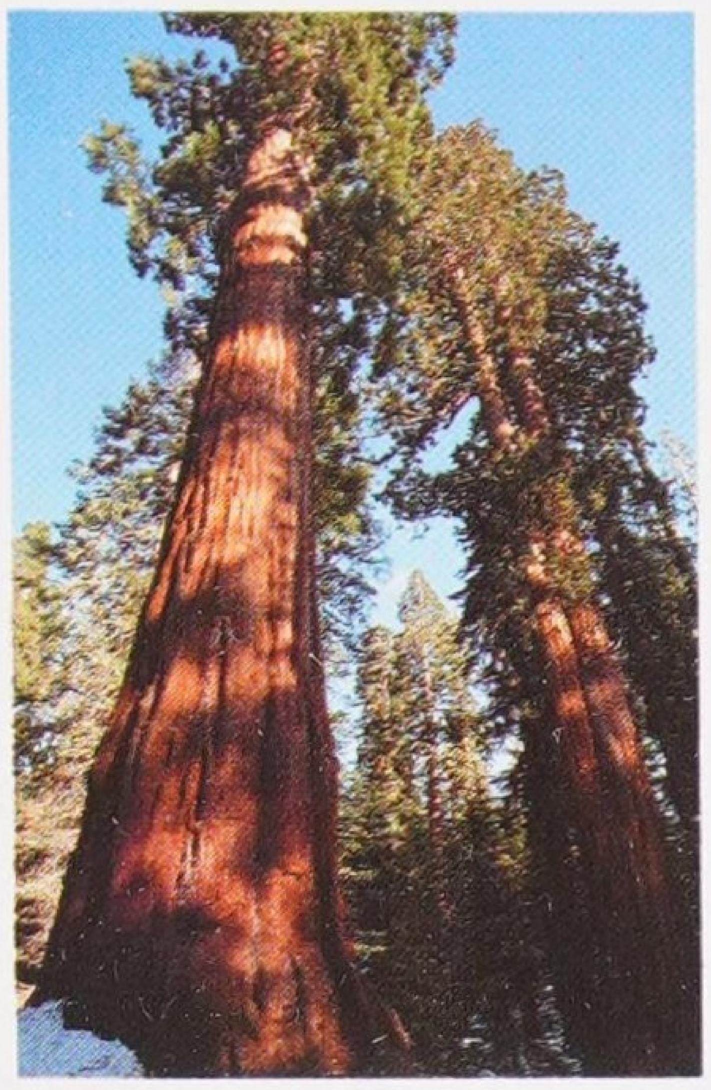
THIS WAS A PLANT
Forests of horsetails and giant clubmosses, up to 150 ft (45 m) tall, once formed a large part of the Earth's vegetation (right). Over 300 million years, their remains have turned into coal.

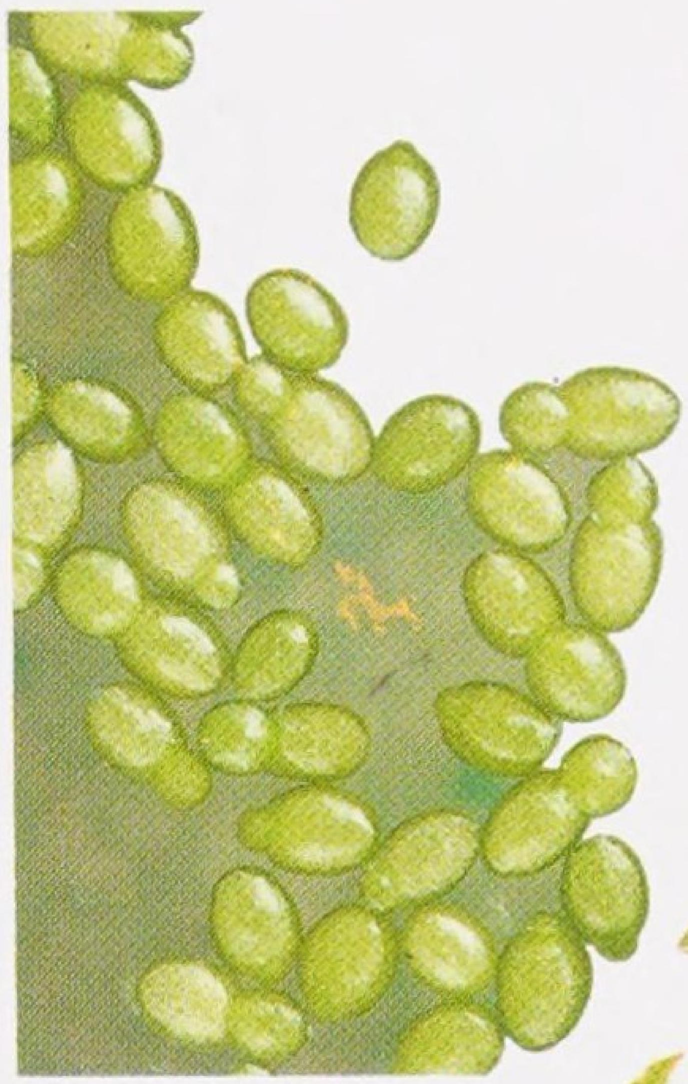
Horsetail



Hart's-tongue fern

MODERN RELATIONS
Ferns and horsetails are primitive plants that do not have flowers but reproduce by spores. Both first appeared nearly 300 million years ago. Although there are still many types of fern, only 30 species of horsetail live on Earth today.





THE BIGGEST AND THE SMALLEST
The world's most massive plants are conifers – the giant sequoias of California, which can reach heights of over 310 ft (95 m). The smallest flowering plant is the rootless duckweed which is 0.01 in (0.3 mm) across.

Garden pansy

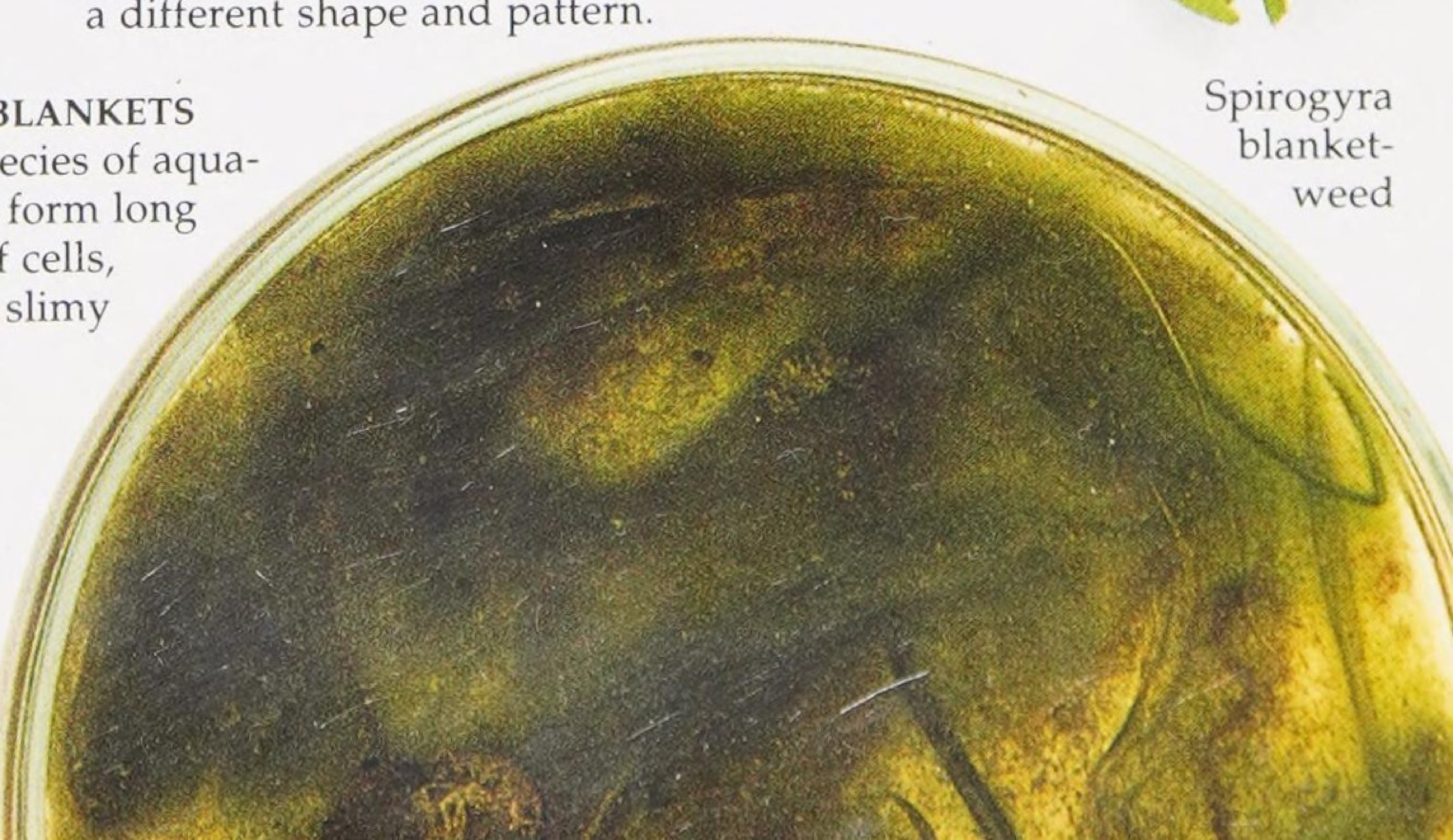
Ribbon-like "thallus" divides into branches as it grows

LIVERWORTS
Liverworts are nonflowering plants that live in damp places and reproduce by means of spores.

MOSSES
Mosses do not have flowers. Like liverworts, they reproduce by means of tiny spores.

LIVING SCULPTURES
Algae are simple, nonflowering plants. A diatom is a single-celled alga which has a rigid transparent case, or frustule, made of silica, a glasslike substance. This microscope photograph shows many species of diatom, each of which has a frustule of a different shape and pattern.

FLOWERING PLANTS
Unlike the other plants on these two pages, these have true flowers. They are also unique in having seeds which develop inside a protective structure called an ovary (p. 17). This later develops into a fruit (pp. 26-27). The garden pansy is a typical flowering plant.

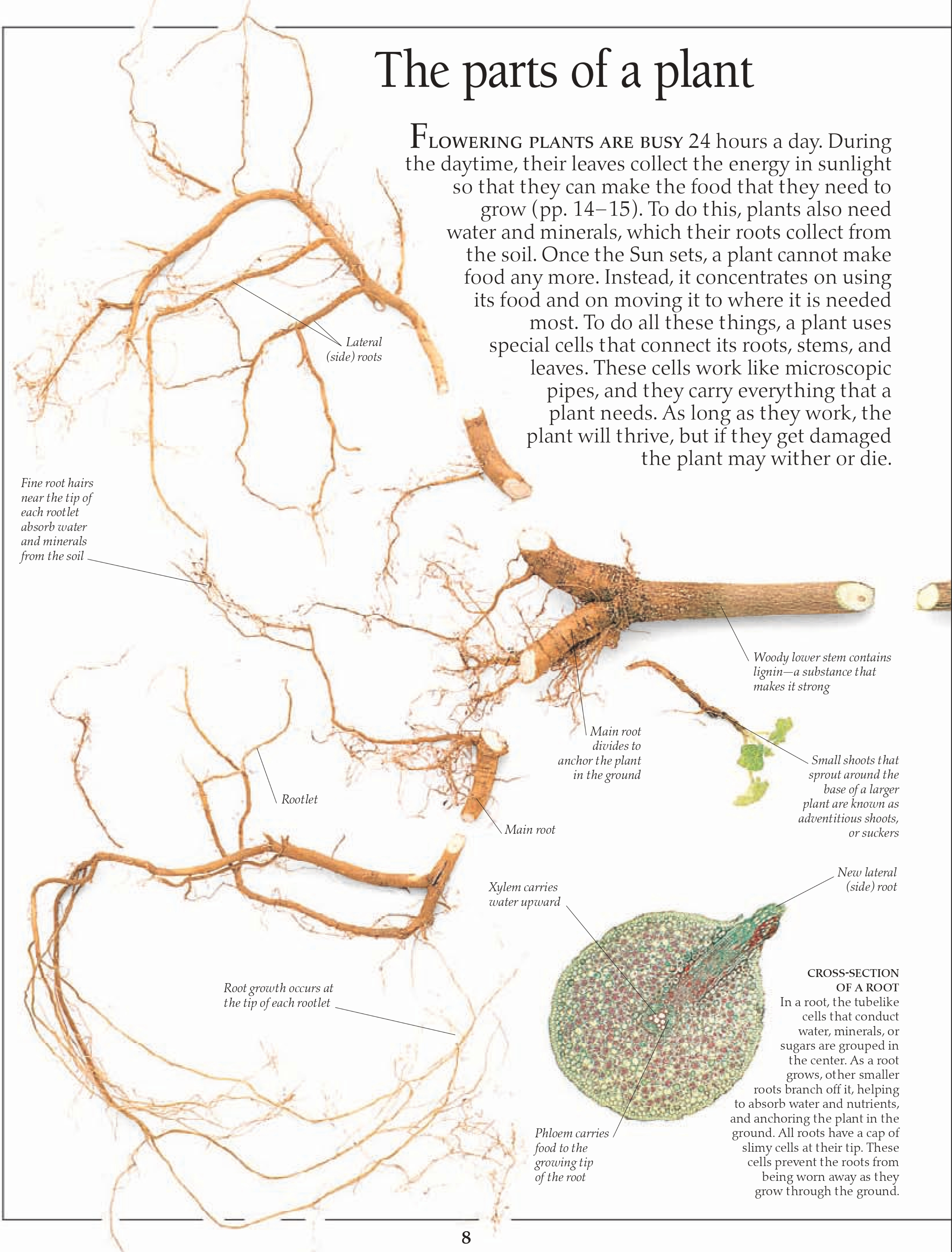


Spirogyra blanket-weed

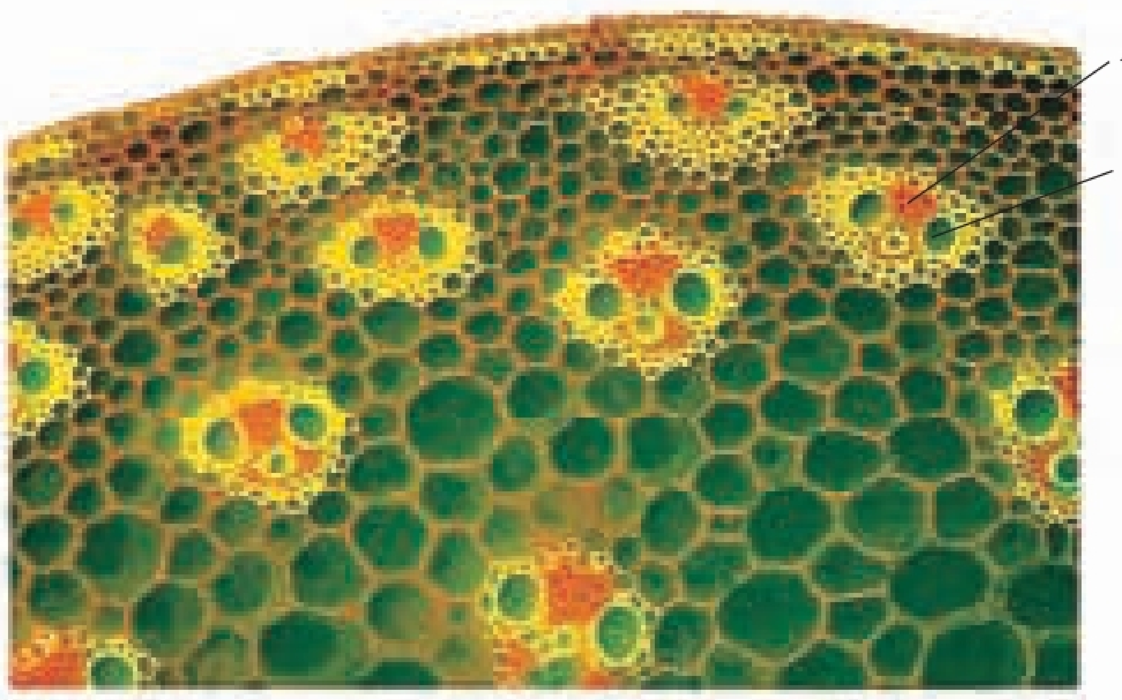
GREEN BLANKETS
Some species of aquatic algae form long chains of cells, creating slimy blanket-weed.

The parts of a plant

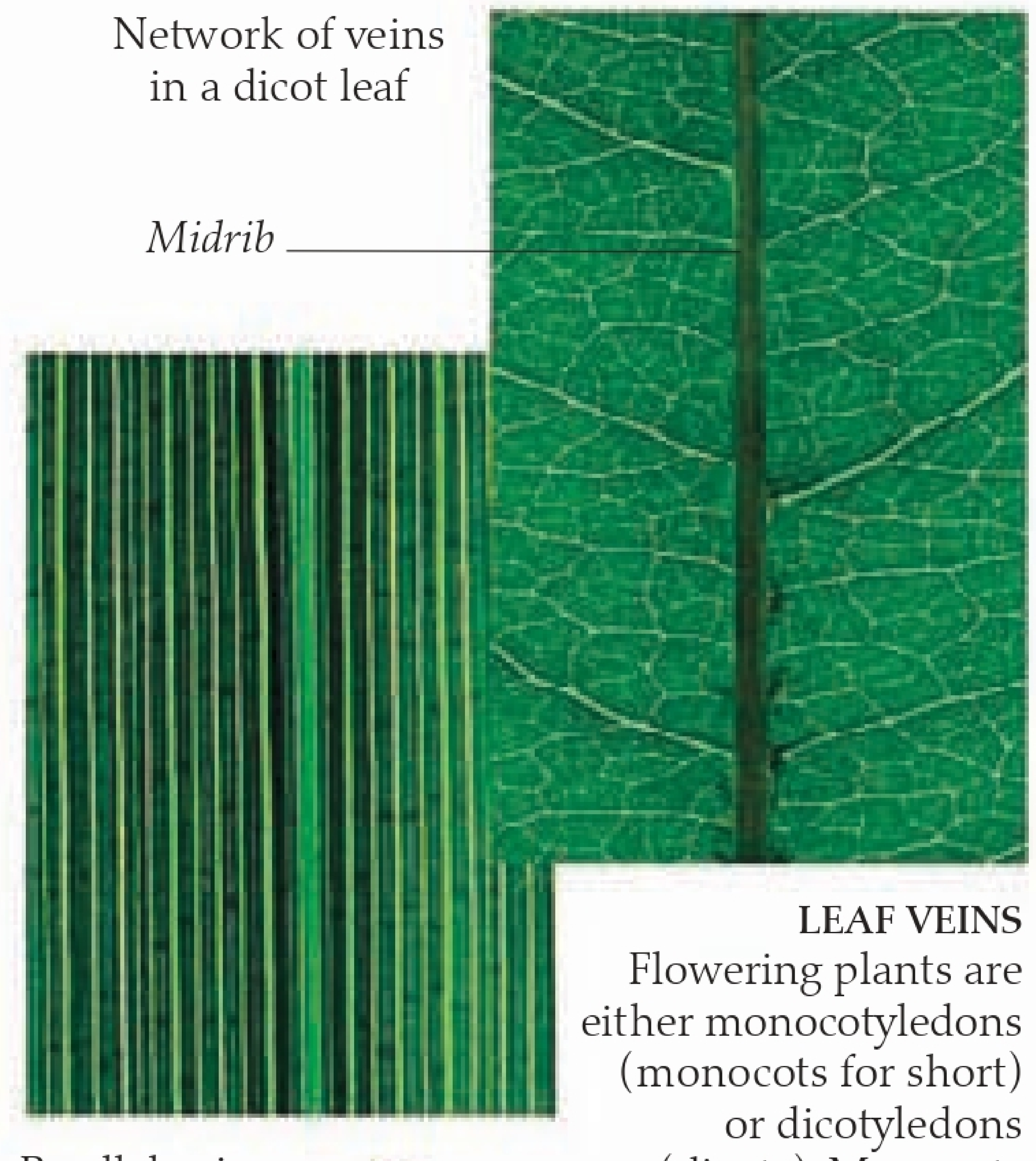
FLOWERING PLANTS ARE BUSY 24 hours a day. During the daytime, their leaves collect the energy in sunlight so that they can make the food that they need to grow (pp. 14–15). To do this, plants also need water and minerals, which their roots collect from the soil. Once the Sun sets, a plant cannot make food any more. Instead, it concentrates on using its food and on moving it to where it is needed most. To do all these things, a plant uses special cells that connect its roots, stems, and leaves. These cells work like microscopic pipes, and they carry everything that a plant needs. As long as they work, the plant will thrive, but if they get damaged the plant may wither or die.



CROSS-SECTION OF A ROOT
In a root, the tubelike cells that conduct water, minerals, or sugars are grouped in the center. As a root grows, other smaller roots branch off it, helping to absorb water and nutrients, and anchoring the plant in the ground. All roots have a cap of slimy cells at their tip. These cells prevent the roots from being worn away as they grow through the ground.



THE SUPPLY SYSTEM
Water, minerals, and food are carried up and down a plant in bundles of tubelike cells. One system, called the xylem, carries water and minerals up the plant. Another, called the phloem, can carry food either upward or downward to whichever parts need it.



LEAF VEINS
Flowering plants are either monocotyledons (monocots for short) or dicotyledons (dicots). Monocots usually have parallel veins in their adult leaves. The adult leaves of dicots usually have a network of veins.

Tree mallow

AN OLD PASTIME
Gardening is by no means a new hobby. This 16th-century gardener certainly seems to know what he is doing, even if some of his tools are slightly different from modern ones.

Woodcut by the 16th-century botanist Clusius, showing the tree mallow in its entirety

FLOWER BUD
The flower bud is covered by protective structures known as sepals.

OPENING BUD
As the petals grow, they extend past the sepals and open to reveal the anthers and stigmas (p. 17), which are the male and female parts of the flower.

FLOWER
The brightly colored petals attract insects that will pollinate the flower. The anthers produce pollen, and the stigmas ripen, ready to receive pollen from other flowers (pp. 22–23).

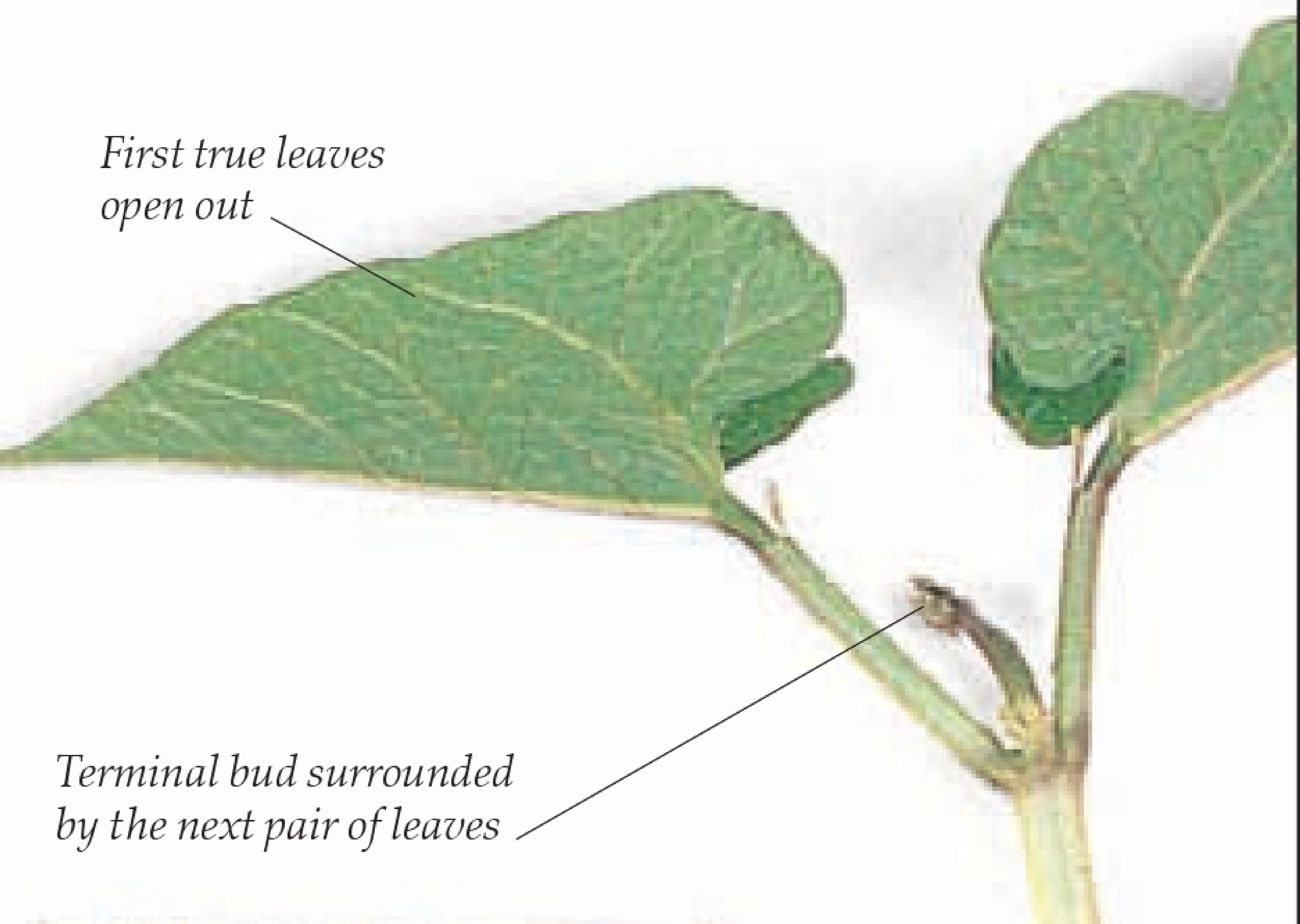
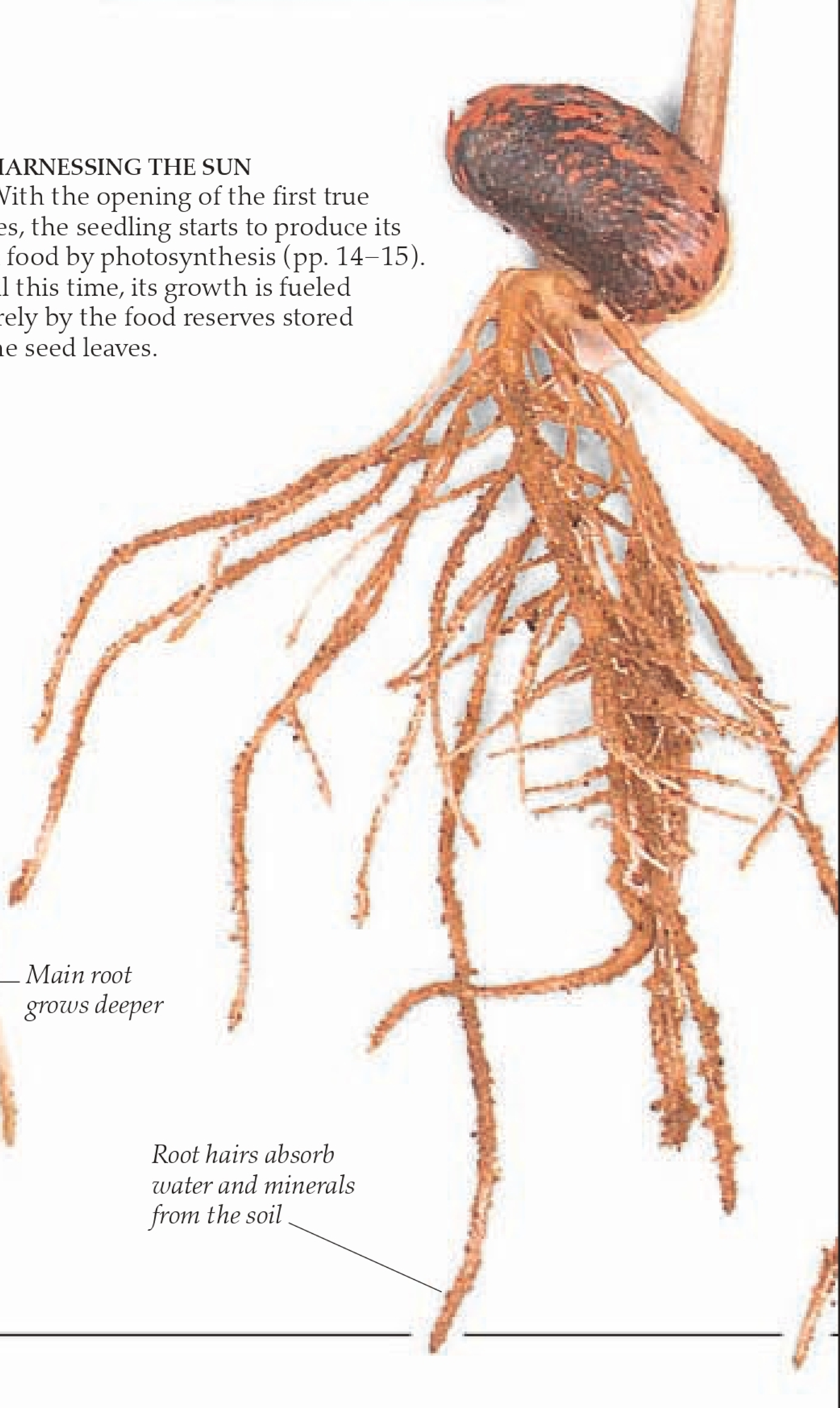
A plant is born

A SEED IS A TINY LIFE-SUPPORT PACKAGE. It contains a plant embryo—the basic parts from which the seedling will develop—together with a supply of food. The food is needed to keep the embryo alive and fuel the process of germination (growth). It is either packed around the embryo, in an endosperm, or stored in special seed leaves, known as cotyledons. For weeks, months, or even years, the seed may remain inactive. But then, when the conditions are right, it suddenly comes alive and begins to grow. During germination the seed absorbs water, the cells of the embryo start to divide, and eventually the seed case, or testa, breaks open. First, the beginning of the root system, or radicle, sprouts and grows downward, followed rapidly by the shoot, or plumule, which will produce the stem and leaves.

1 GETTING GOING
The seed of a scarlet runner will germinate only if it is dark and damp. First, the skin of the seed splits. The beginning of the root system, the radicle, appears and starts to grow downward. Shortly after this, a shoot appears, initially bent double with its tip buried in the seed leaves. This shoot, or plumule, will produce the stem and leaves.

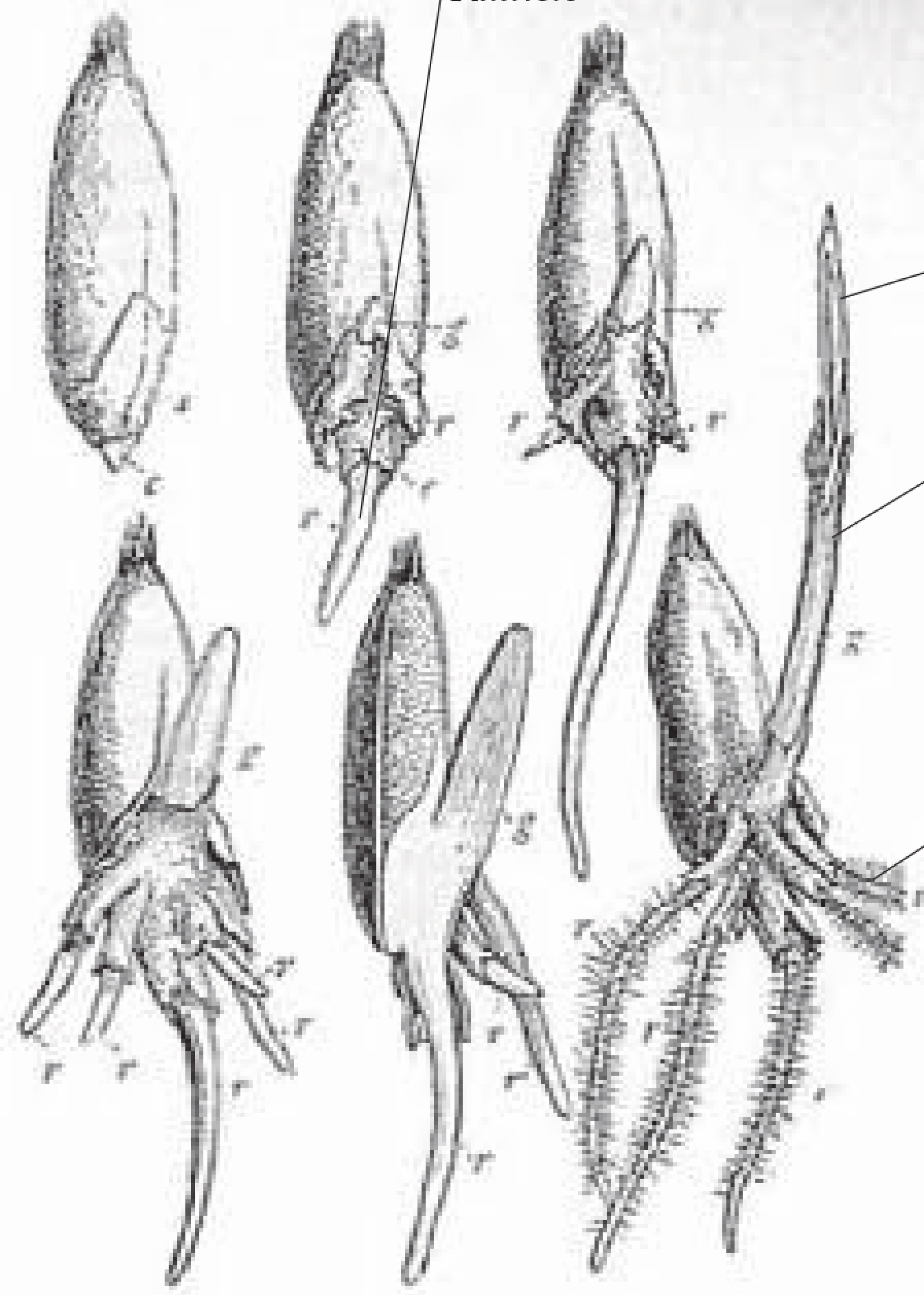
2 REACHING FOR THE LIGHT
As the plumule grows longer, it breaks above ground. Once it is above the soil, it straightens up toward the light, and the first true leaves appear. In the scarlet runner, the seed leaves stay buried. This is called hypogeal germination. In plants such as the sunflower, the seed leaves are lifted above ground, where they turn green and start to produce food for the seedling. This is known as epigeal germination.

TINY BUT STRONG
When plants grow, they can exert great pressure. Some seedlings can easily push through the surface of a new road.

3 HARNESSING THE SUN
With the opening of the first true leaves, the seedling starts to produce its own food by photosynthesis (pp. 14–15). Until this time, its growth is fueled entirely by the food reserves stored in the seed leaves.

GERMINATING GRAIN
Wheat is a monocot, which means that it has just one seed leaf (p. 9). The young shoot grows upward through the soil, protected by a tube called a coleoptile. As with all grasses, the growing point, or apical meristem, of the leaves of the wheat plant is at ground level and can continue to produce new shoots at the base of the plant, even if the leaves are removed. This is why pasture can survive being nibbled by cows, and why lawns thrive on being mown. Other plants, such as the bean, have their growing region, or meristem, near the tip. If they are mown or nibbled, they must grow out from side buds instead.

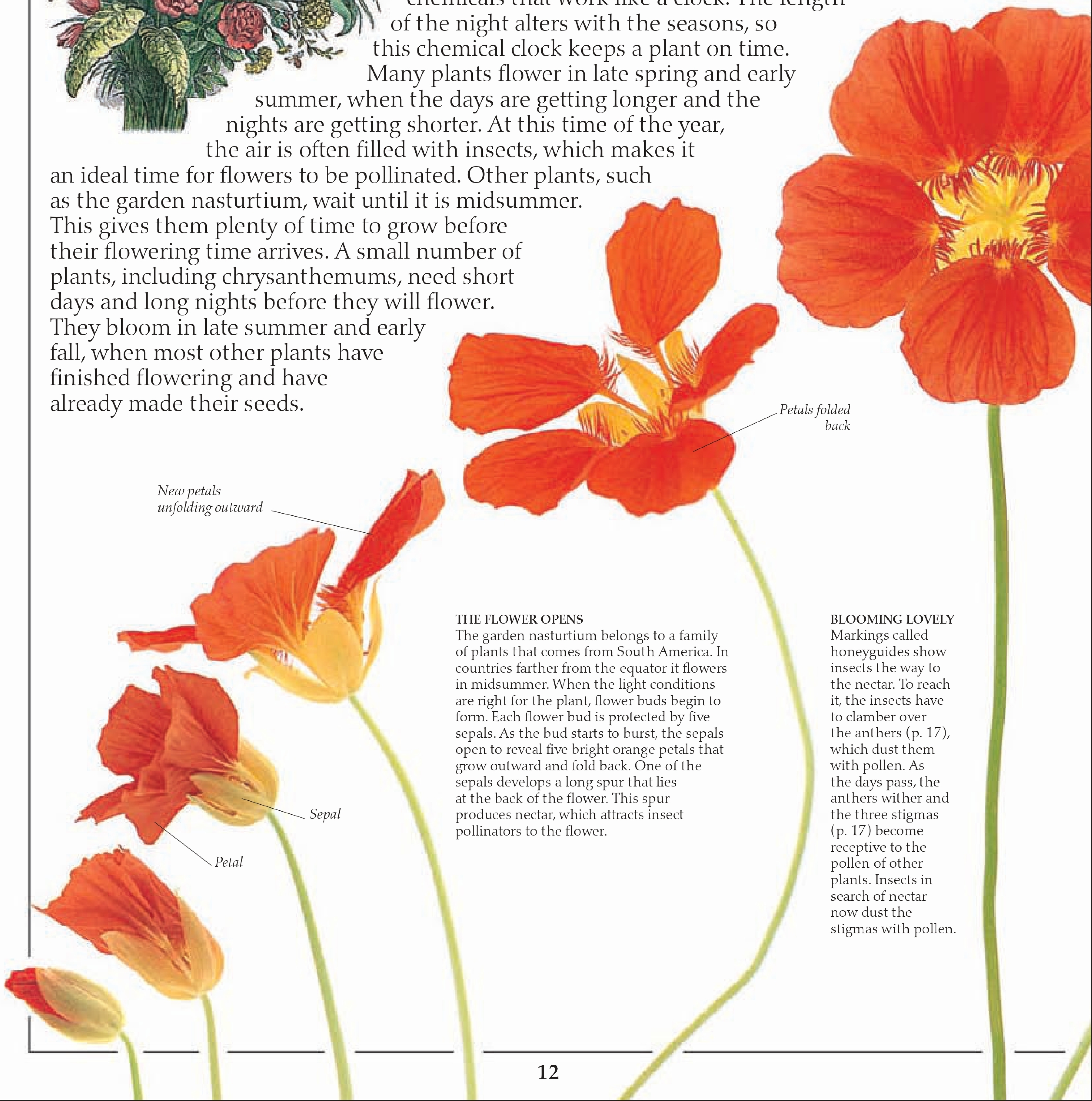


4 THE RACE TO REPRODUCE
Once germination is complete, the scarlet runner grows quickly. Because it is a climbing plant, it does not need to develop thick stems. Instead, it uses other plants for support (p. 38). Given the right conditions, the plant will produce its first flowers in six weeks. After pollination (pp. 22–23) and fertilization, these will develop into pods full of seeds. By the time the seeds have dried out, the life cycle of the scarlet runner has turned full circle.

A YEARLY CYCLE
Some plants produce underground storage organs, such as bulbs, tubers, and corms (pp. 32–33). Every fall the leaves of lords-andladies die, but the following spring new leaves develop from buds on the tuber. Although this process may look very similar to germination, it is very different.

Bursting into bloom

All plants have special control systems that make sure that they flower at the right time. Some need lots of warmth, and others will only flower after the ground has been soaked by rain. But for many, the most important trigger for flowering is the length of the night. Plants cannot see the difference between night and day, but they can sense it with special chemicals that work like a clock. The length of the night alters with the seasons, so this chemical clock keeps a plant on time. Many plants flower in late spring and early summer, when the days are getting longer and the nights are getting shorter. At this time of the year, the air is often filled with insects, which makes it an ideal time for flowers to be pollinated. Other plants, such as the garden nasturtium, wait until it is midsummer. This gives them plenty of time to grow before their flowering time arrives. A small number of plants, including chrysanthemums, need short days and long nights before they will flower. They bloom in late summer and early fall, when most other plants have finished flowering and have already made their seeds.

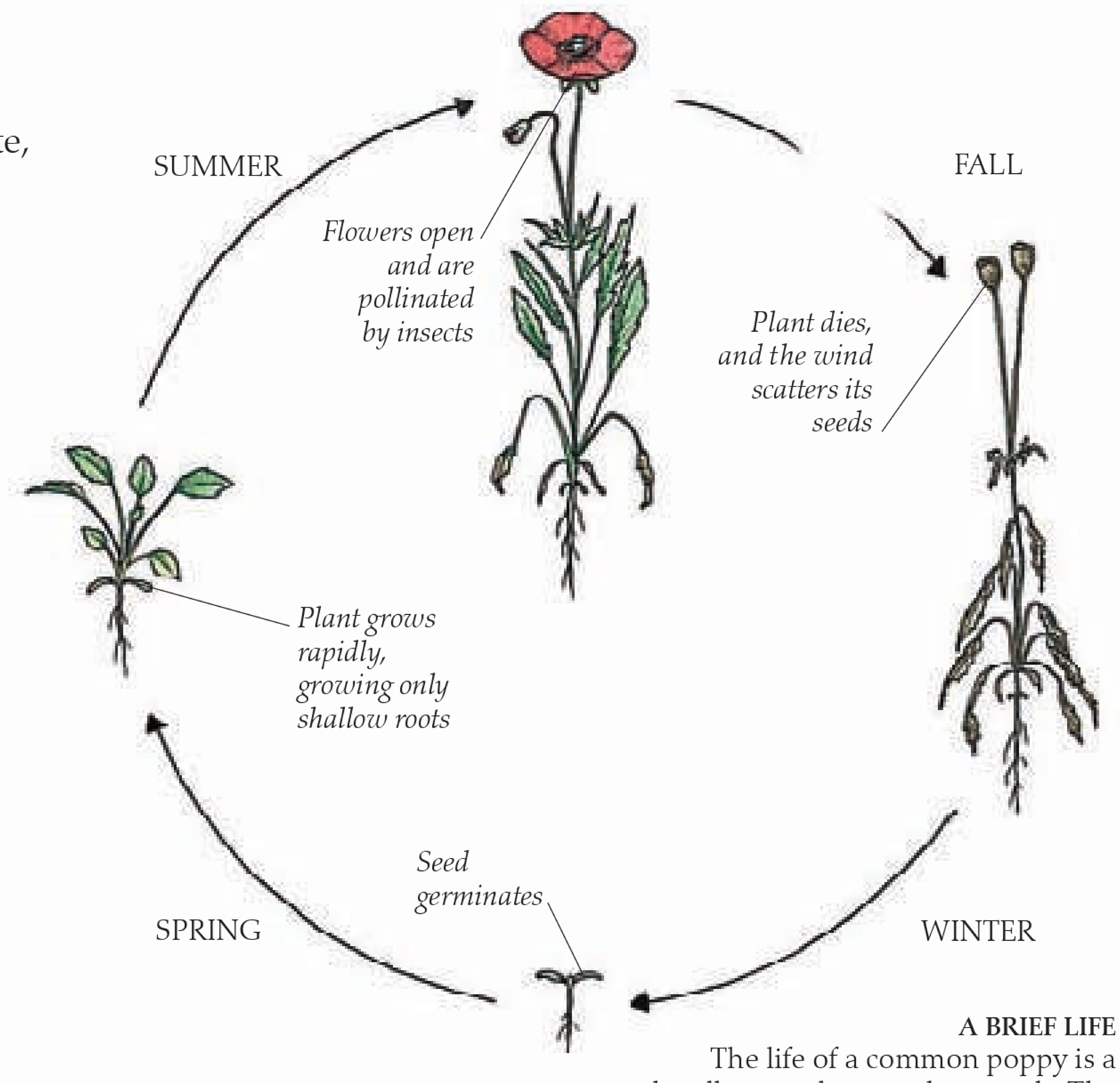


THE FLOWER OPENS
The garden nasturtium belongs to a family of plants that comes from South America. In countries farther from the equator it flowers in midsummer. When the light conditions are right for the plant, flower buds begin to form. Each flower bud is protected by five sepals. As the bud starts to burst, the sepals open to reveal five bright orange petals that grow outward and fold back. One of the sepals develops a long spur that lies at the back of the flower. This spur produces nectar, which attracts insect pollinators to the flower.

BLOOMING LOVELY
Markings called honeyguides show insects the way to the nectar. To reach it, the insects have to clamber over the anthers (p. 17), which dust them with pollen. As the days pass, the anthers wither and the three stigmas (p. 17) become receptive to the pollen of other plants. Insects in search of nectar now dust the stigmas with pollen.

The life cycles of plants

Flowering plants have very different lifespans, ranging from months to centuries. A common poppy will germinate, flower, set seed, and die, all within a single year. Plants that live in this way are known as annuals. Other plants, such as the wild carrot (p. 55), take two years to complete the same process. They flower only in their second year—the first is spent growing and building up food reserves, which they store in a thick, fleshy root. These plants are known as biennials. Perennial plants are those that live for a number of years. They include species such as the dandelion (pp. 30–31). Perennial weeds are a particular problem for gardeners because their long lifespan gives them time to grow very wide-spreading roots.



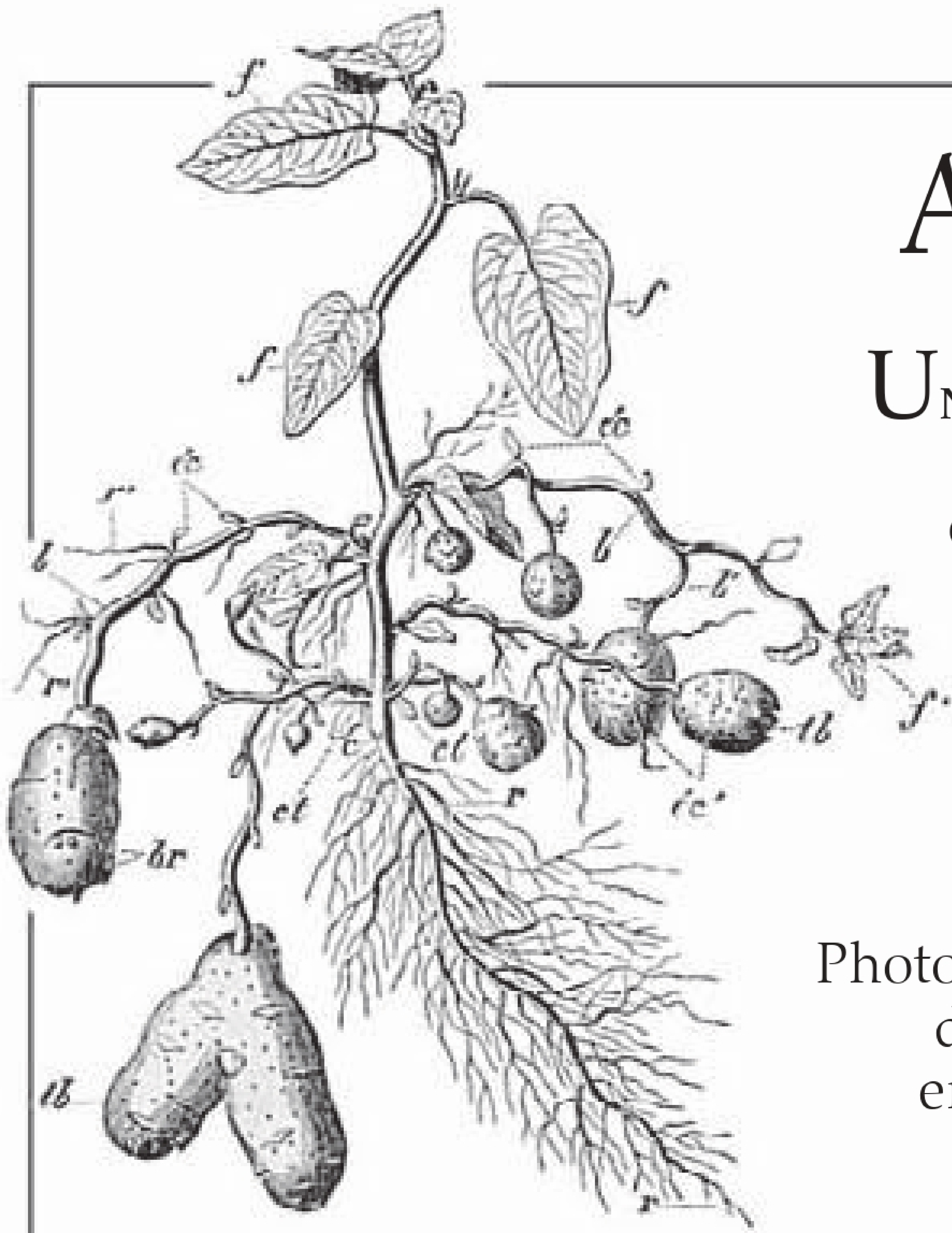
A BRIEF LIFE
The life of a common poppy is a headlong rush to produce seeds. The seeds from the previous year germinate early in the spring. The young plant grows rapidly, producing only shallow roots. Flower buds appear in early summer, and by midsummer the flowers are open, ready to be pollinated by insects. As soon as they have been pollinated, the flowers wither, and seeds are produced in a pod. The plant dies in the fall, and its seeds are shaken out by the wind. And so the cycle begins again.

FADING FAST
Each nasturtium flower lasts for a number of days, receiving dozens of insect visitors searching for nectar. After the flower has been pollinated, the petals' work is over. The cells begin to lose water, making them shrivel up. The flower may look as if it is dying, but the parts that remain are very much alive.

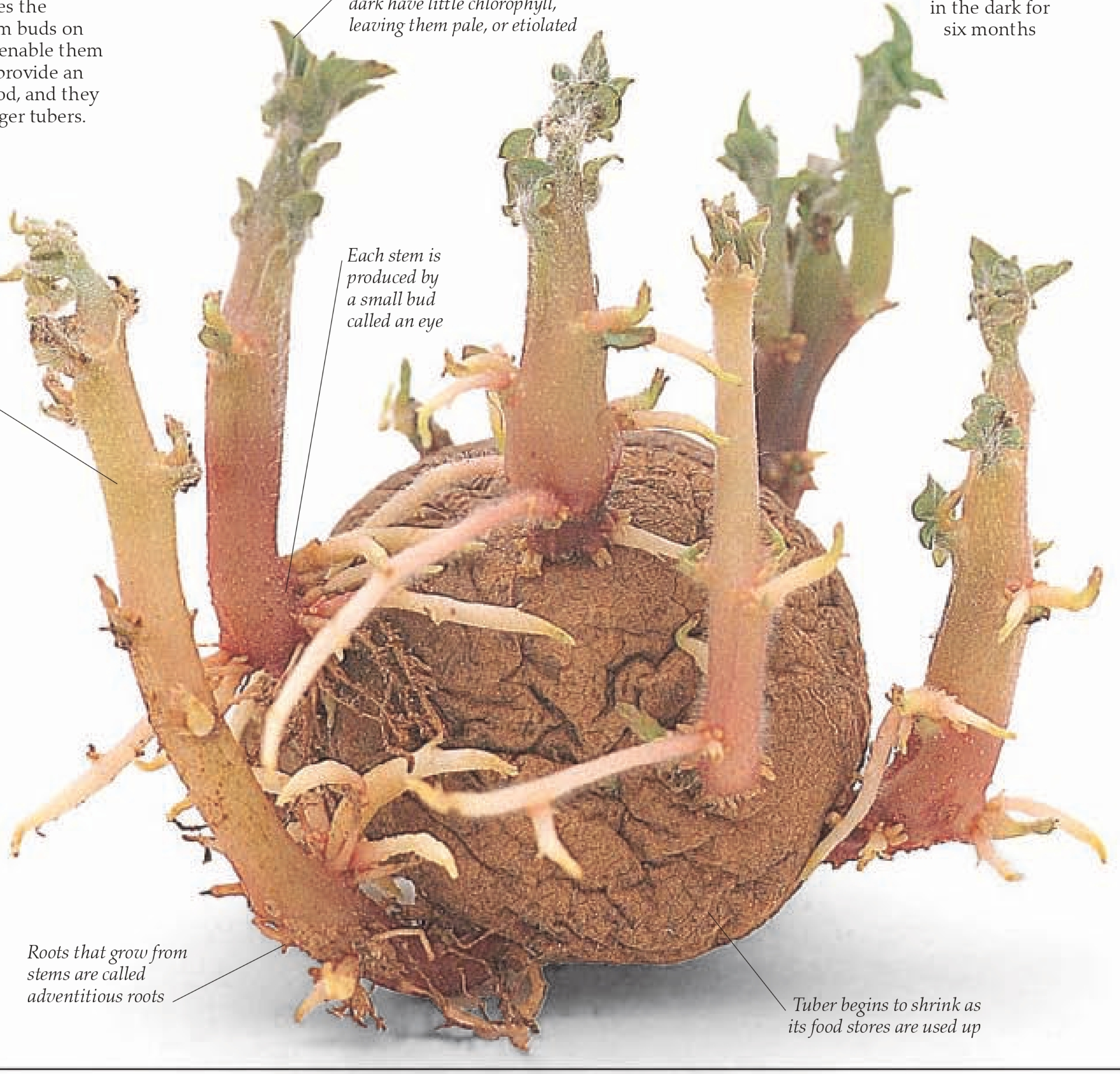
GOING TO SEED
After the petals and sepals have fallen away, each flower produces three seeds inside a fruit (p. 31). Like all parts of the nasturtium plant, the seeds and the flesh that surrounds them are rich in a bitter-tasting oil. The fruits are sometimes picked when they are still green, for use in cooking.

A light diet

Unlike animals, plants do not need to find food, because they can make it for themselves. The key to this is a substance called chlorophyll, which makes leaves green. Plants use chlorophyll to trap the energy in sunlight. Once they have done this, the plants can put the energy to work. They use it to make water combine with carbon dioxide, a gas that they get from the air. The result is glucose—an energy-rich food sugar that plants use to grow. This process is called photosynthesis, which means putting together with light. Photosynthesis works like a bonfire in reverse. While a bonfire breaks down living things and gives out energy, photosynthesis takes in energy and uses it to build up the living parts of plants. Thanks to photosynthesis, plants make billions of tons of food every year. Without it, most of the living world would soon come to a halt, because plants make the food that other living things need to survive.



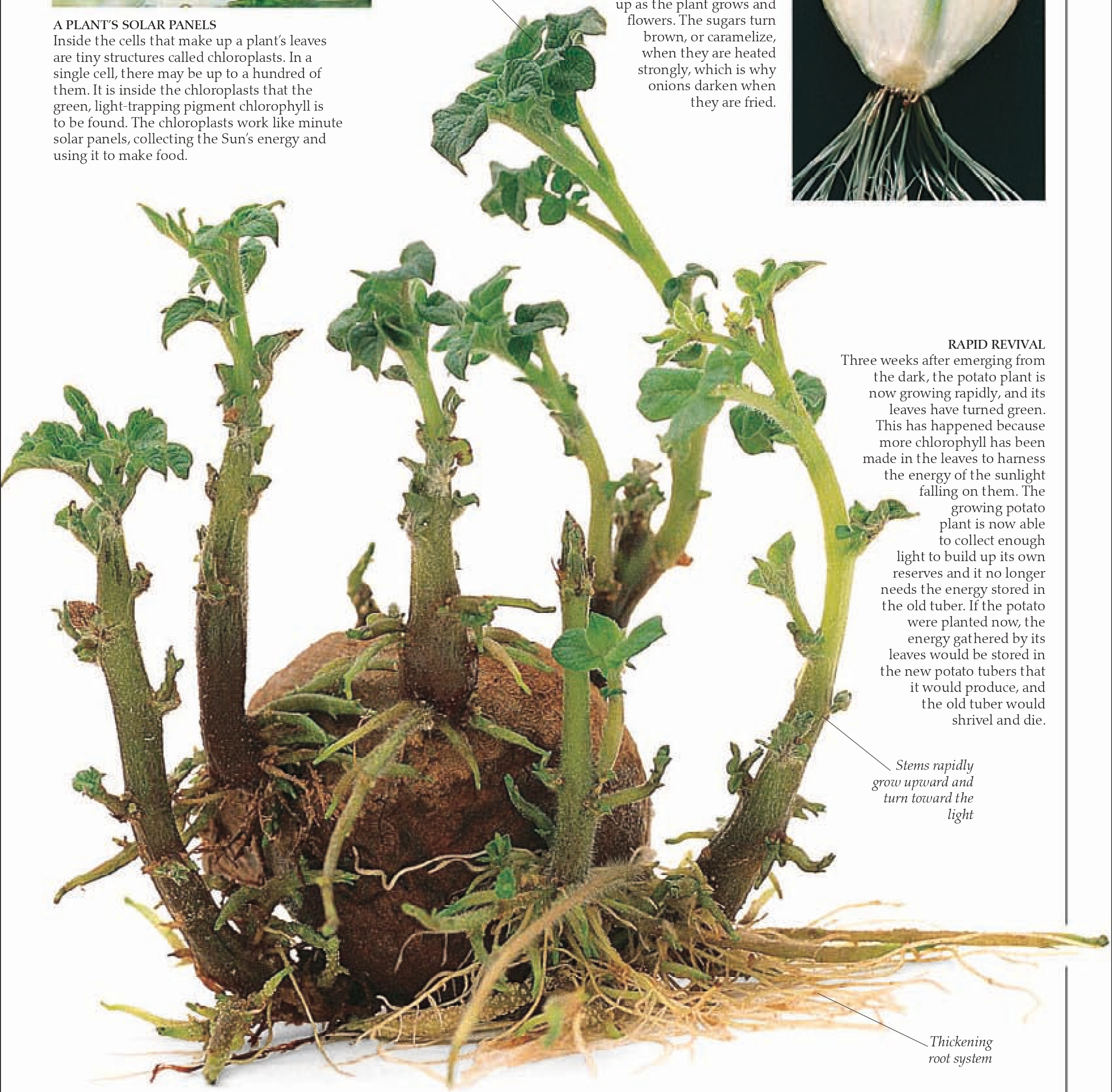
UNDERGROUND STORAGE
Potatoes are swollen underground stems, known as tubers, which store the food produced by photosynthesis. This food, in the form of starches, provides the young shoots that develop from buds on the tuber with enough fuel to enable them to grow quickly. Potatoes also provide an important source of human food, and they have been bred to produce bigger tubers.



A PLANT WITHOUT LIGHT
This potato has spent six months with very little light—conditions that would kill many plants. Because it has been in almost complete darkness, the young potato has not been able to produce any food by photosynthesis. However, it has survived and has even produced some roots and shoots, which have drawn on the food reserves stored by the parent plant during the previous year's growth. The parent potato plant used the Sun's energy to make food, which it stored in its tubers, mostly in the form of grains of starch. The young potato plants use the starch to release energy for growth.

A PLANT'S SOLAR PANELS
Inside the cells that make up a plant's leaves are tiny structures called chloroplasts. In a single cell, there may be up to a hundred of them. It is inside the chloroplasts that the green, light-trapping pigment chlorophyll is to be found. The chloroplasts work like minute solar panels, collecting the Sun's energy and using it to make food.

STORING SUGAR
Plants store food in various ways—as starches, sugars, or oils. In its first year, an onion plant stores sugars in the onion bulb, which is made up of swollen leaf bases around a shortened stem. In the second year, the sugars in the onion bulb are used up as the plant grows and flowers. The sugars turn brown, or caramelize, when they are heated strongly, which is why onions darken when they are fried.

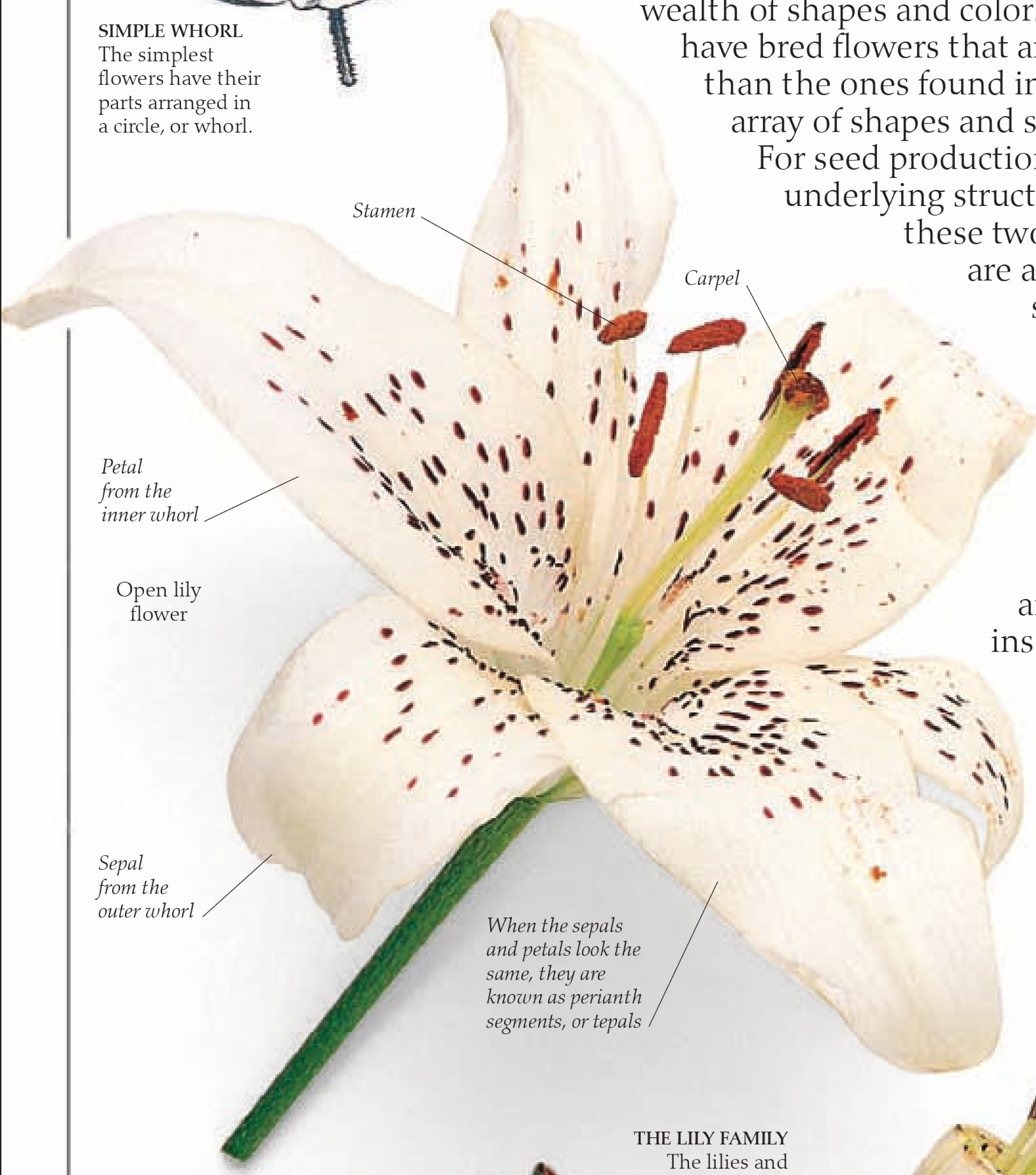


RAPID REVIVAL
Three weeks after emerging from the dark, the potato plant is now growing rapidly, and its leaves have turned green. This has happened because more chlorophyll has been made in the leaves to harness the energy of the sunlight falling on them. The growing potato plant is now able to collect enough light to build up its own reserves and it no longer needs the energy stored in the old tuber. If the potato were planted now, the energy gathered by its leaves would be stored in the new potato tubers that it would produce, and the old tuber would shrivel and die.

A simple flower dissected

SIMPLE WHORL
The simplest flowers have their parts arranged in a circle, or whorl.

Flowers have become extraordinarily varied during the course of evolution. Nature has produced them in a tremendous wealth of shapes and colors. Added to this profusion, people have bred flowers that are even more brilliant or bizarre than the ones found in the wild. But behind this baffling array of shapes and sizes there is a common pattern. For seed production, all flowers use the same underlying structures. The lily flower shown on these two pages is quite simple—its parts are all separate, and they can all be seen clearly. They fall into three groups. The male parts (the stamens) produce the pollen, while the female parts (the carpel) include the ovary, where seeds are produced. Around both the male and the female parts are sepals and petals, which attract insects to the flower.

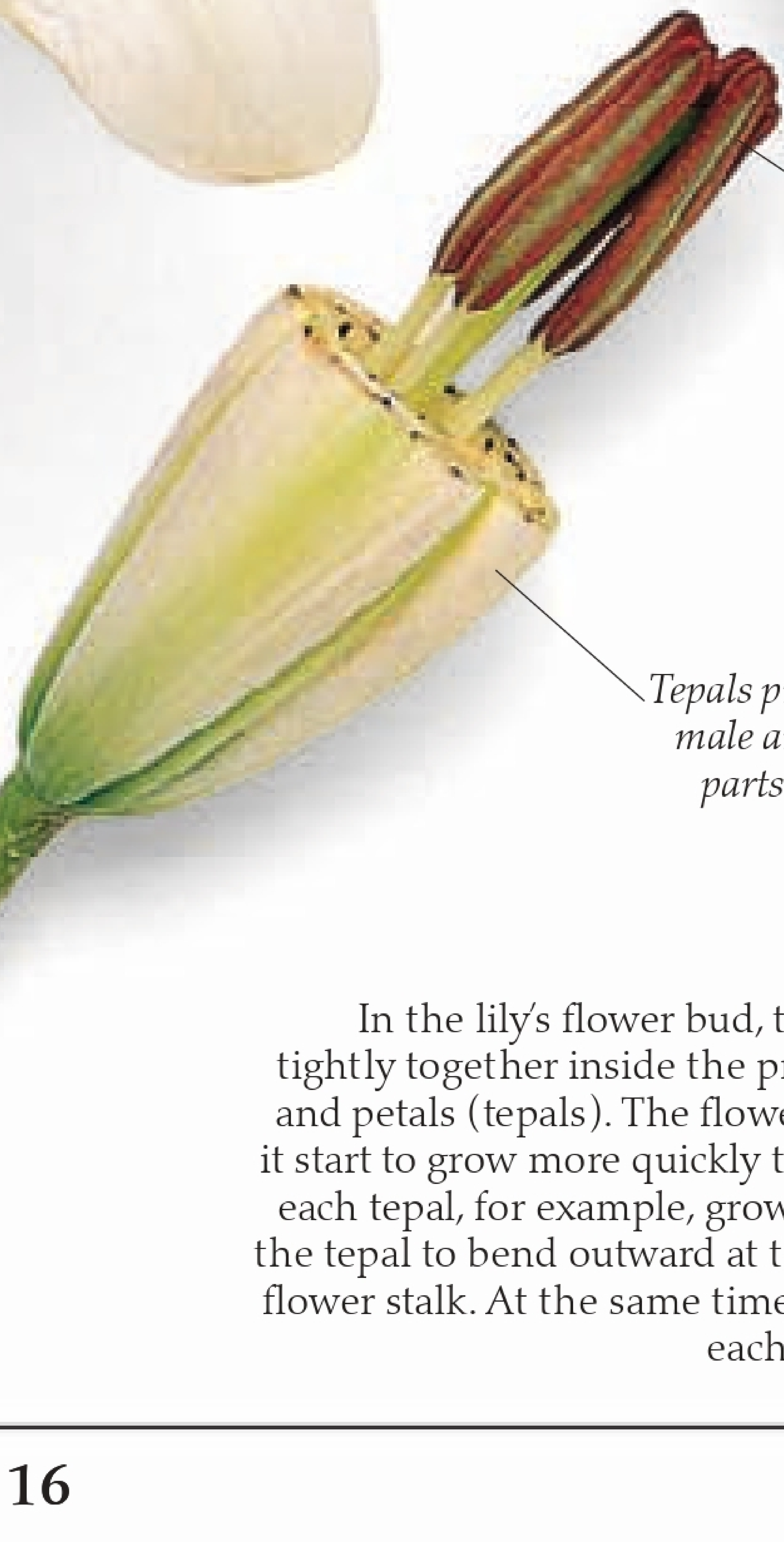


Petal from the inner whorl

Open lily flower

Sepal from the outer whorl

Lily flower bud

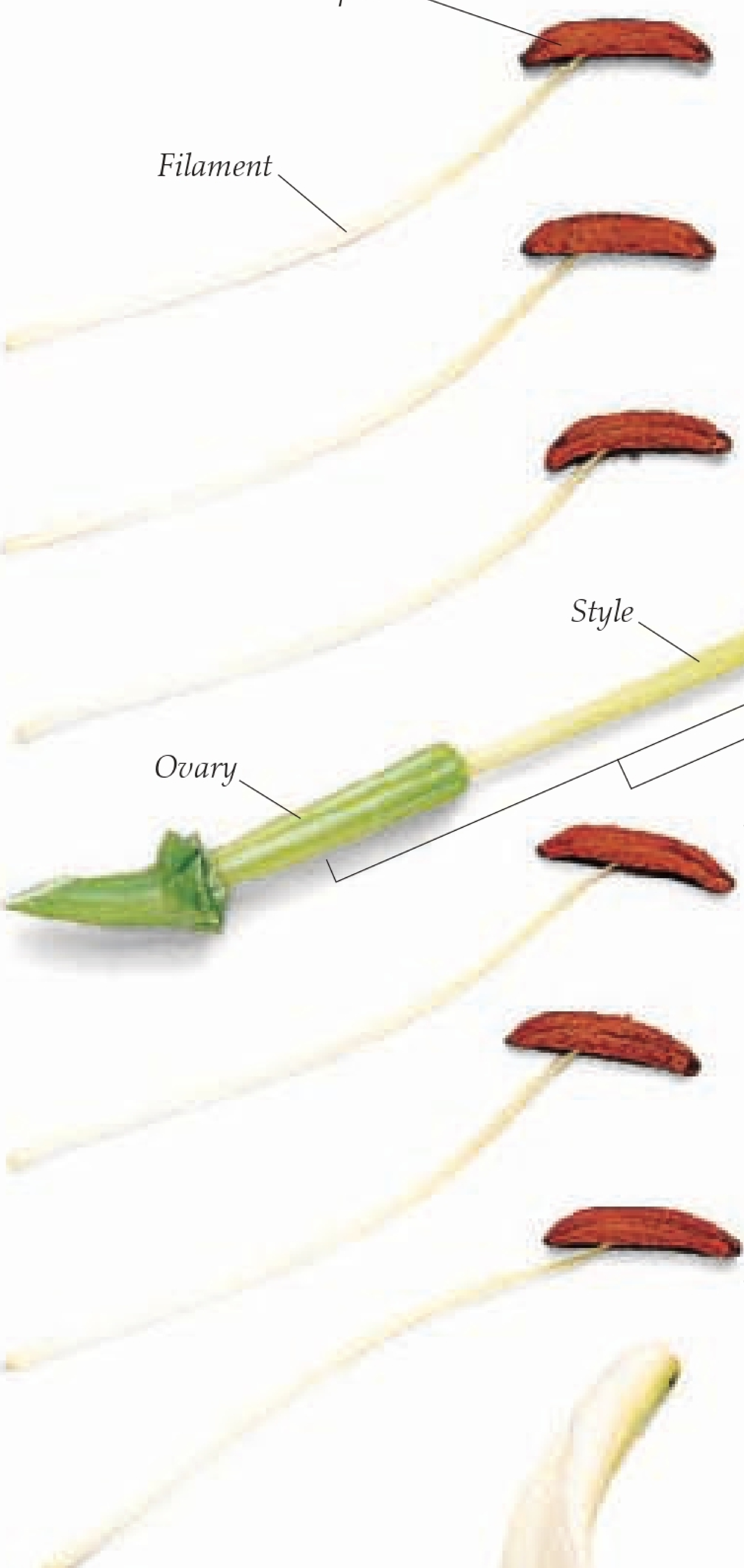


Stamens and the carpel are packed tightly together

Tepals protecting the male and female parts of the flower

THE LILY FAMILY
The lilies and their relatives make up one of the largest families of flowering plant.

HOW A FLOWER BUD OPENS
In the lily's flower bud, the male and female parts are packed tightly together inside the protective casing formed by the sepals and petals (tepals). The flower bud opens because certain parts of it start to grow more quickly than others. The inside of the base of each tepal, for example, grows faster than the outside. This forces the tepal to bend outward at the point where it is connected to the flower stalk. At the same time, unequal growth along the edges of each tepal makes the folds in it open out.

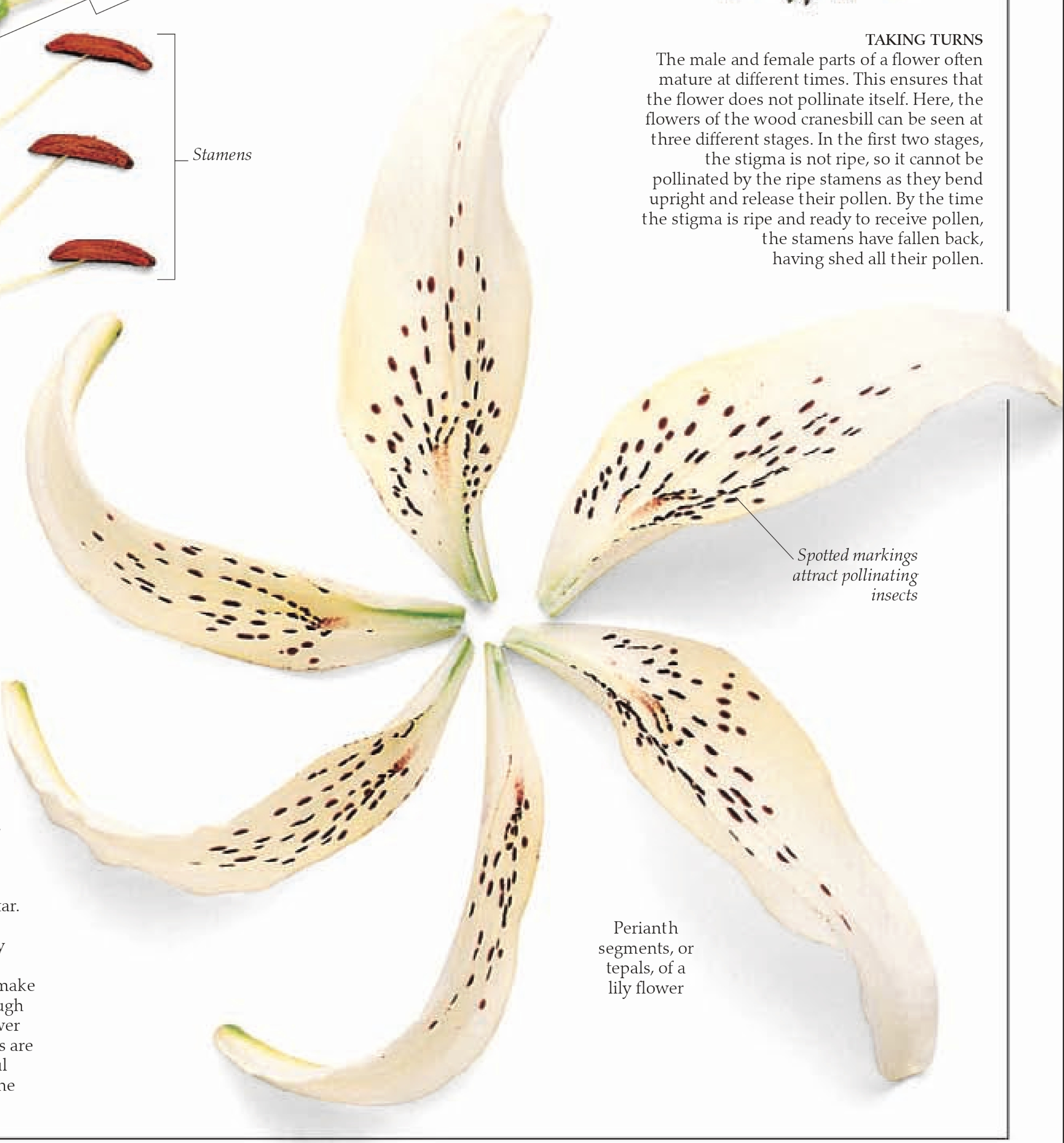


REPRODUCTIVE PARTS

The lily flower contains both male and female parts. The female parts, or carpels, are at the center of the flower. They consist of the ovary, where the seeds are produced, and the stigma, which is attached to the ovary by the style. The stigma is the part of the flower that receives pollen during pollination (pp. 22–23). The male parts of the flower consist of six identical stamens. Each stamen is made up of an anther, which produces the pollen, supported by a filament. As soon as the pollen is ripe, the anthers split open. When an insect visits the flower, some of the pollen brushes off on to its body and will be carried off to pollinate the stigma of another flower.

TAKING TURNS

The male and female parts of a flower often mature at different times. This ensures that the flower does not pollinate itself. Here, the flowers of the wood cranesbill can be seen at three different stages. In the first two stages, the stigma is not ripe, so it cannot be pollinated by the ripe stamens as they bend upright and release their pollen. By the time the stigma is ripe and ready to receive pollen, the stamens have fallen back, having shed all their pollen.

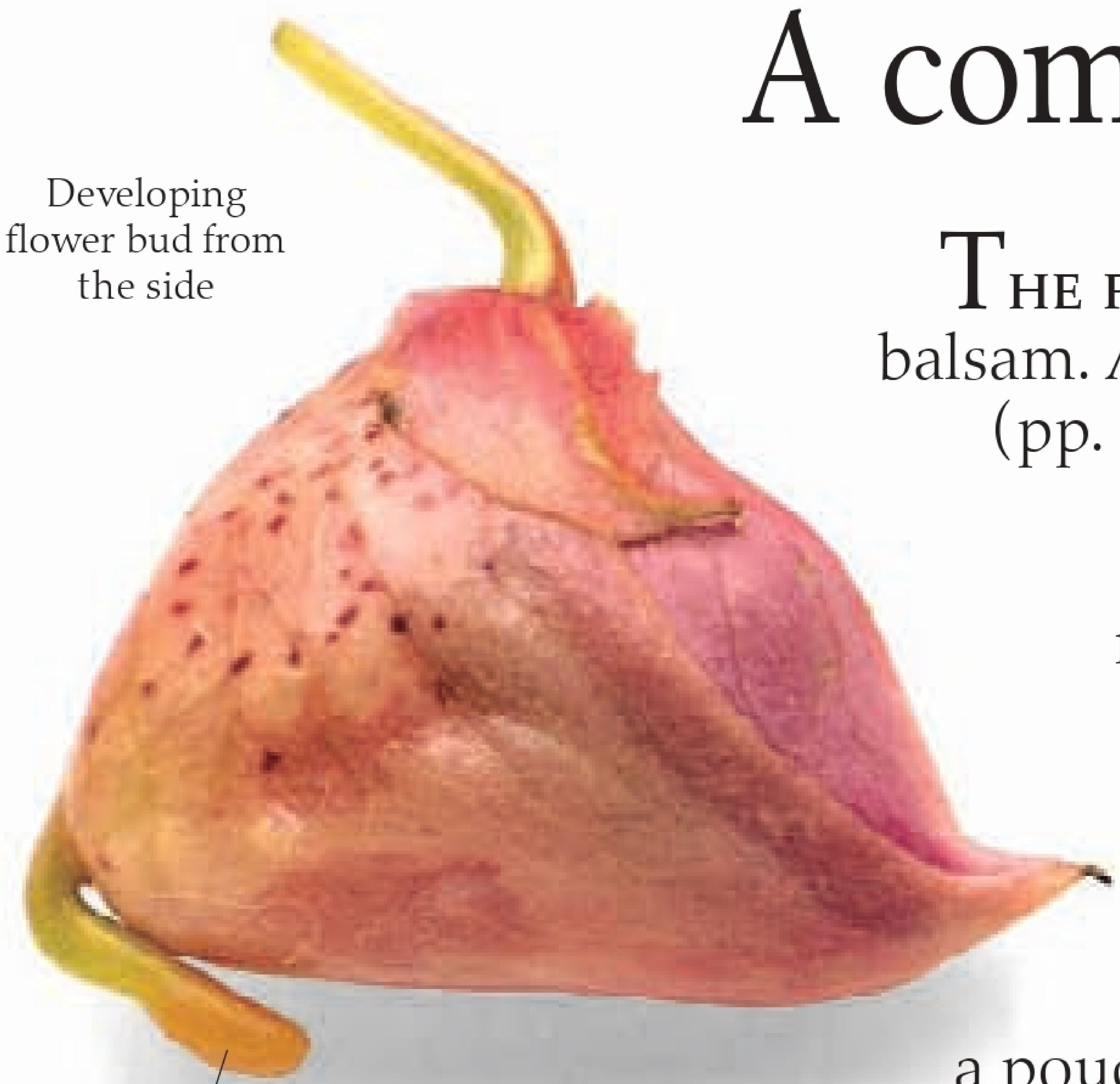


Perianth segments, or tepals, of a lily flower

STAR ATTRACTION

Surrounding the male and female parts of the lily flower is an outer ring, or whorl, of three white sepals, and an inner whorl of three white petals. Because both sepals and petals are identical, they are known as tepals. In the lily flower these tepals work like advertising signs to attract insects in search of nectar. However, not all flowers are like this. In many flowers, only the inner whorl of petals is conspicuous. The sepals that make up the outer whorl may be tough and green and protect the flower bud. In some plants, the sepals are much bigger and more colorful than the petals and perform the task of attracting insects.

A complex flower

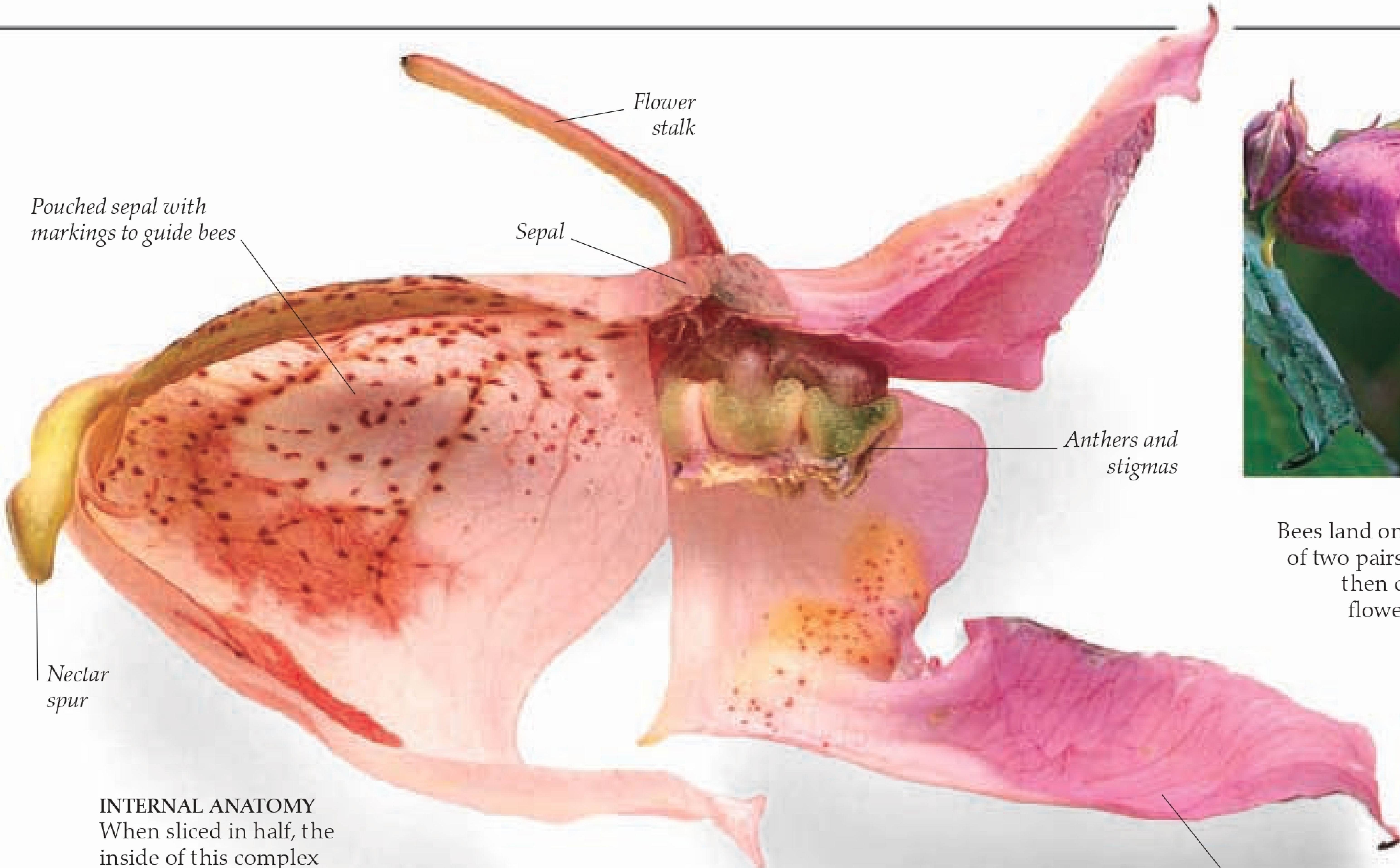


THE FLOWERS ON THESE TWO PAGES come from the Himalayan balsam. Although they have the same basic parts as the lily flower (pp. 16–17), evolution has modified them in different ways so that the two flowers look completely different. Compared with the lily flower, the flowers of the balsam are much more complex and specialized. Himalayan balsam flowers are pollinated by long-tongued insects, such as bees, and they are shaped to ensure that an insect picks up the grains of pollen from the anthers when it approaches and enters the flower. Bees are attracted to the flower by sugary nectar, which is produced in a spur attached to a pouch at the back of the flower. To reach this nectar, a visiting bee first has to land on a platform made up of petals. It then has to climb right inside the flower and stretch out its long tongue. When the bee is in this position, its back touches the anthers. These give it a dusting of pollen, which is carried to the next flower the bee visits.

A PAT ON THE BACK
A passion flower has three stigmas, unlike the lily, which has just one. Insects seek out the nectar produced in the base of the passion flower. When the passion flower opens, the anthers, which are lower than the styles (p. 17), dust pollen on to a visiting insect's back. A few hours later, the styles curve downward so that the stigmas are lower than the empty anthers. This enables the stigmas to collect pollen from another insect's back.

Fully formed flower from the side

ATTRACTIVE TO INSECTS
Himalayan balsam flowers each have three sepals and five petals, and are symmetrical in as far as each half is a mirror image of the other. Two of the sepals are small flaps at the base of the flower. They protect the young flower bud. During millions of years of evolution, the third sepal has become much larger and is shaped like a pouch. At the end of this pouch lies the narrow spur that produces nectar.



INTERNAL ANATOMY
When sliced in half, the inside of this complex flower is revealed.

CLIMBING ABOARD
Bees land on a platform made up of two pairs of joined petals and then crawl deep inside the flower to reach the nectar.

Bee's-eye view of the front of the flower

Anthers and stigmas removed from flower

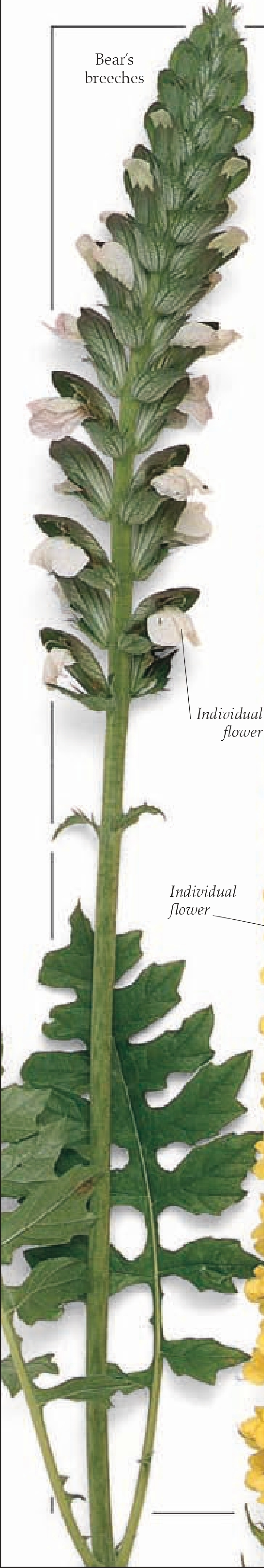
FROM FLOWER TO SEED
Bees are drawn to the flower by the brightly colored petals. Once the flower has been pollinated, the petals fall off. The female part of the flower then grows longer to form a five-sided capsule that contains the seeds. The seeds are shed when the fully grown capsule explodes (p. 29).

Young seed capsule

Mature seed capsule

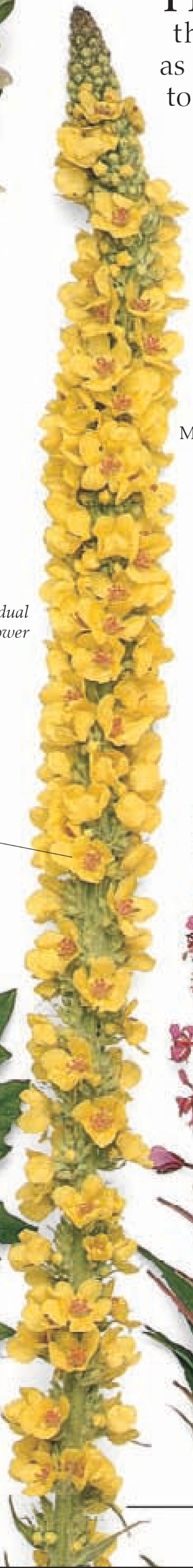
All sorts of flowers

HOW MANY INDIVIDUAL FLOWERS are there on these two pages? The question is not as simple as it sounds. You would need a magnifying glass to work out the answer, because the final figure adds up to at least 3,300. Some plants, such as the tulip, each have just a single flower. Others, like the dog rose, have a lot of flowers, but each one develops and blooms separately. Many other plants—including most of the plants on these two pages—produce flowers grouped together in clusters known as flower heads. Flower heads have many different shapes, and they vary widely in size and in the number of flowers they contain. The world's biggest individual flower, produced by the giant rafflesia (pp. 44–45), is completely dwarfed by the world's biggest flower head: this is grown by the rare South American puya, which reaches a height of nearly 33 ft (10 m).



Bear's breeches

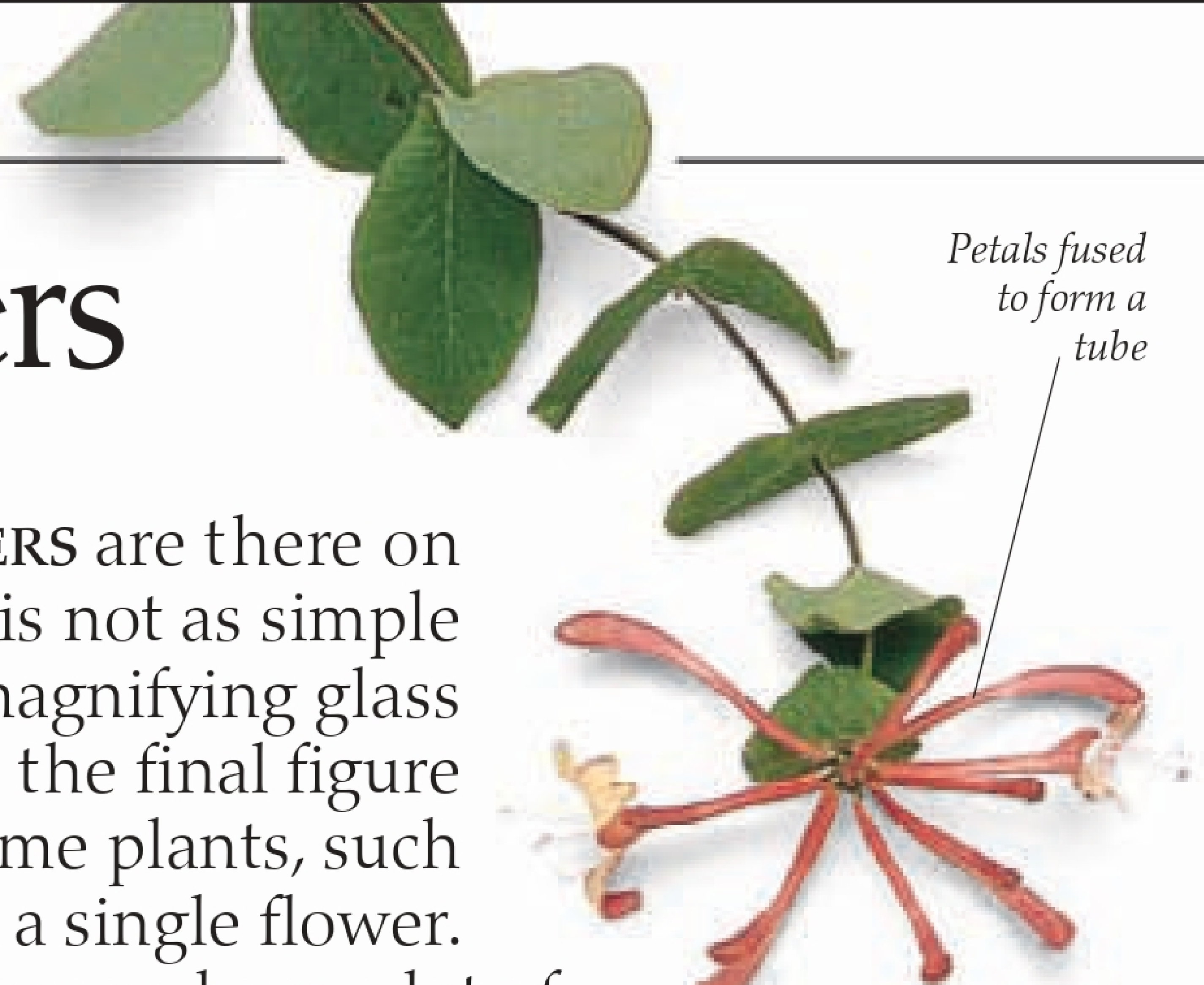
Individual flower



Mullein

Individual flower

Rosebay willowherb



Petals fused to form a tube

Honeysuckle

Dog rose

REGULAR FLOWERS

A regular flower, such as the dog rose (see above), has all its parts—sepals, petals, anthers, and stigma—arranged on a simple circular plan.

Tudor coin

Dog-rose design

The iris is a regular flower that can be cut symmetrically into three pieces

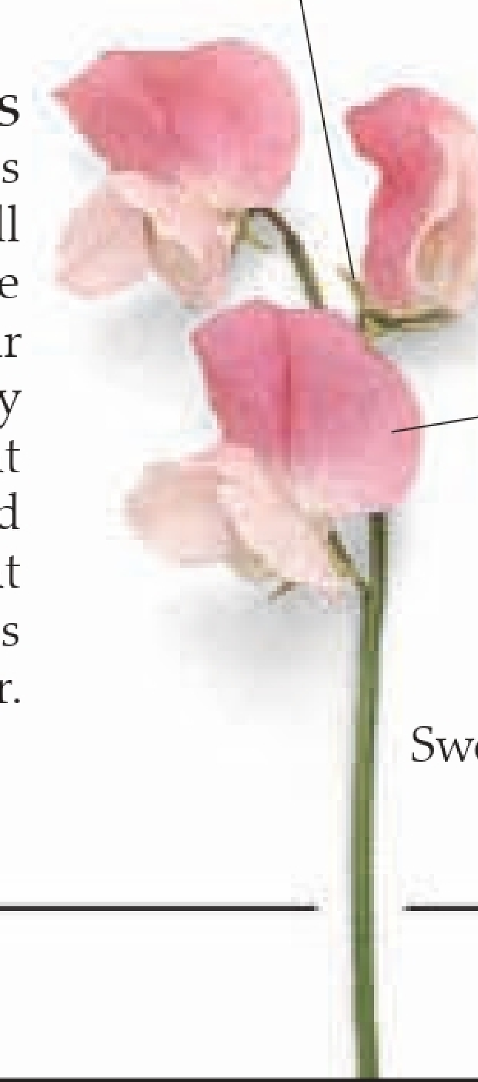
Iris

FLOWER SPIRES

Flowers in spires (see left) usually open in sequence, starting at the bottom. This sequence may take a number of weeks to complete. By the time the last flower has opened, the first may already have set seed.

IRREGULAR FLOWERS

An irregular flower, such as the sweet pea, is still symmetrical, but in a more limited way. Most irregular flowers are bilaterally symmetrical, meaning that they can be divided into two halves that are mirror images of each other.



Sepal

Petal

Sweet pea

SHOWY TEPALS

The sepals and petals of some flowers, like the clematis, are so similar that it is difficult to tell them apart. These parts are known as tepals (p. 16) and may be brightly colored.

COMPOSITE FLOWERS

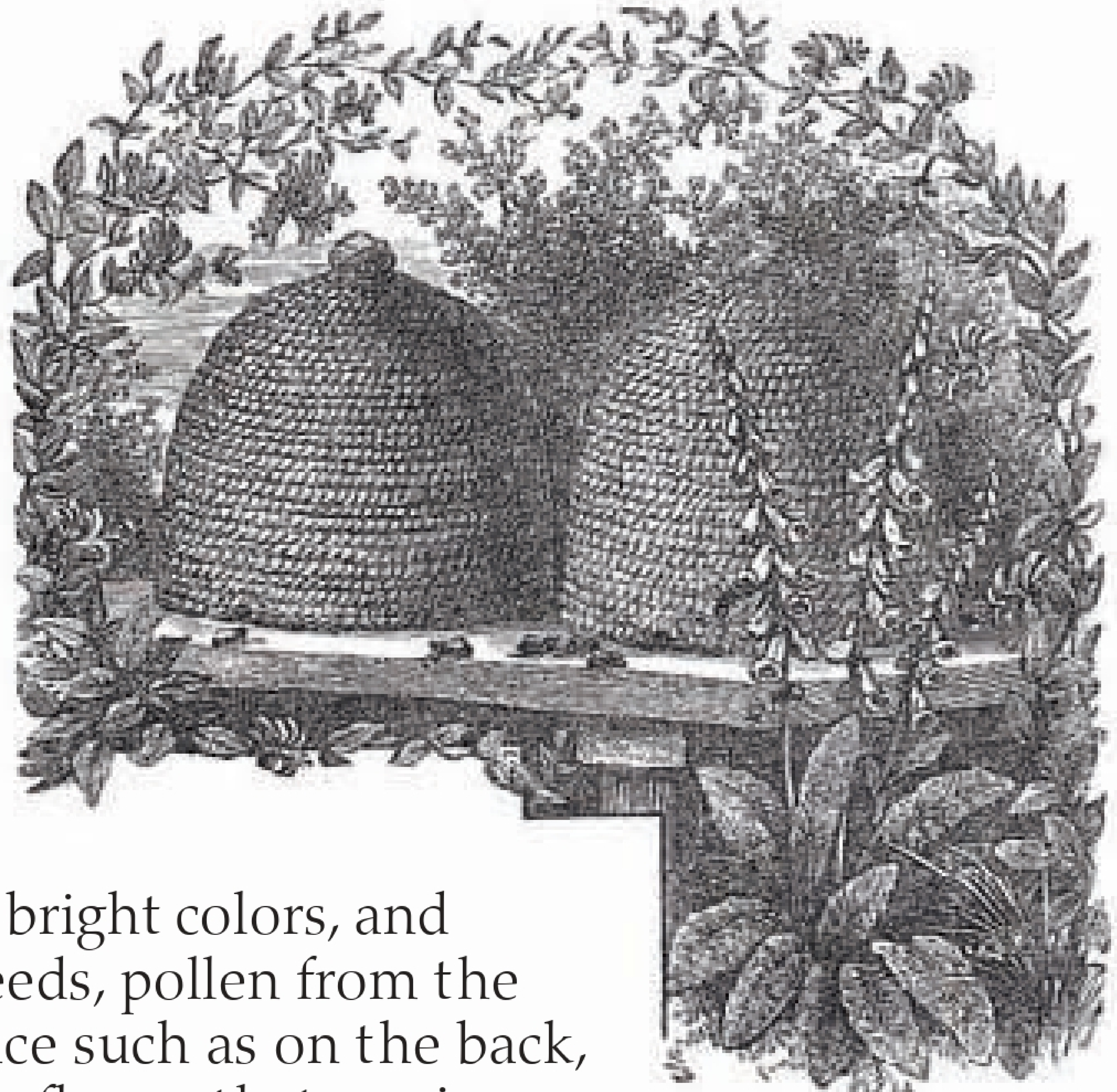
The flower heads of plants such as sunflowers and daisies are known as composite flowers, because they are composed of many tiny flowers called florets clustered together. Sunflower heads have many hundreds of florets—disk florets in the center of the flower head, and ray florets, which consist of a single petal-like ray around the outer edge. In the yarrow (see below), each flower head is made up of many individual disk florets surrounded by about five ray florets. These flower heads are crowded together to form a bigger cluster of about 1,000 florets.

FLOWERS IN UMBELS

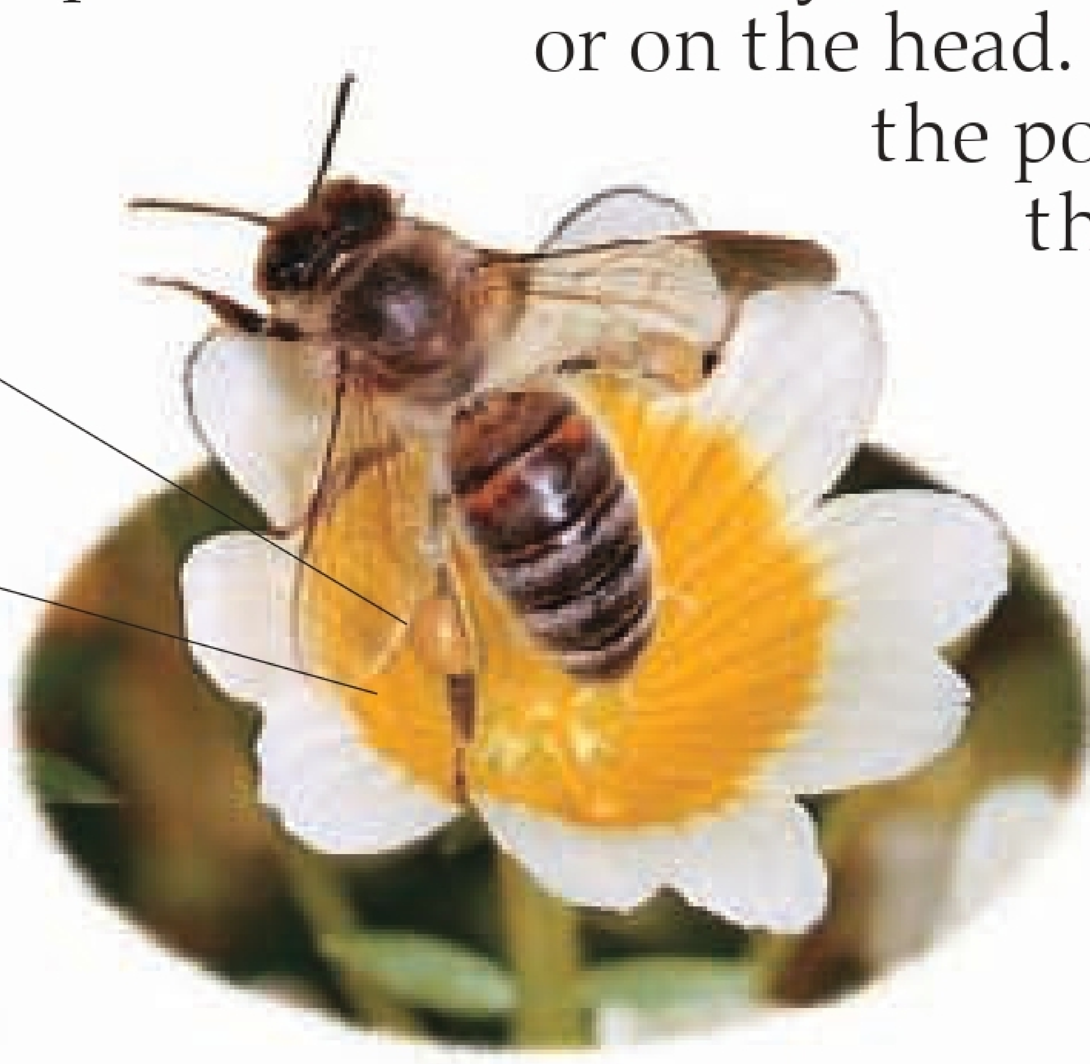
Not only are small flowers more visible when they are clustered together, but flower clusters also provide a better landing platform for pollinating insects. Plants in the family known as the umbellifers, such as hogweed (see right), have their flowers grouped together in umbrella-shaped clusters called umbels. Eryngo (see left) is an unusual umbellifer, since it has dome-shaped umbels.

How a plant is pollinated

THE FASCINATING SHAPES and brilliant colors of many flowers have evolved over millions of years to make sure that tiny grains of pollen are carried from one plant to another. Pollen grains have to travel from the anthers to the stigma (pp. 16–17) for fertilization to occur and for seeds to be produced. Some plants are able to pollinate themselves (selfpollination), but most rely on receiving pollen from another plant of the same species (cross-pollination). Pollen may be dispersed by wind or by water, but the most important pollinators are insects. Plants entice insects to their flowers by their bright colors, and by food in the form of nectar. While the visiting insect feeds, pollen from the anthers is pressed on to its body, often at a particular place such as on the back, or on the head. The stigma of the flower that receives the pollen is in just the right place to collect it as the insect arrives. Some flowers are pollinated by a wide range of insects such as honeybees, bumblebees, hoverflies, and butterflies. Others are more choosy and rely so heavily on a particular pollinator that no other insect species can do the job for them. Some species of yucca, for example, are pollinated exclusively by a small moth, called the yucca moth. In return, the yucca provides the moth with food and a home.



FAMILY HOME
Worker bees bring nectar and pollen back to the hive to feed the developing young.

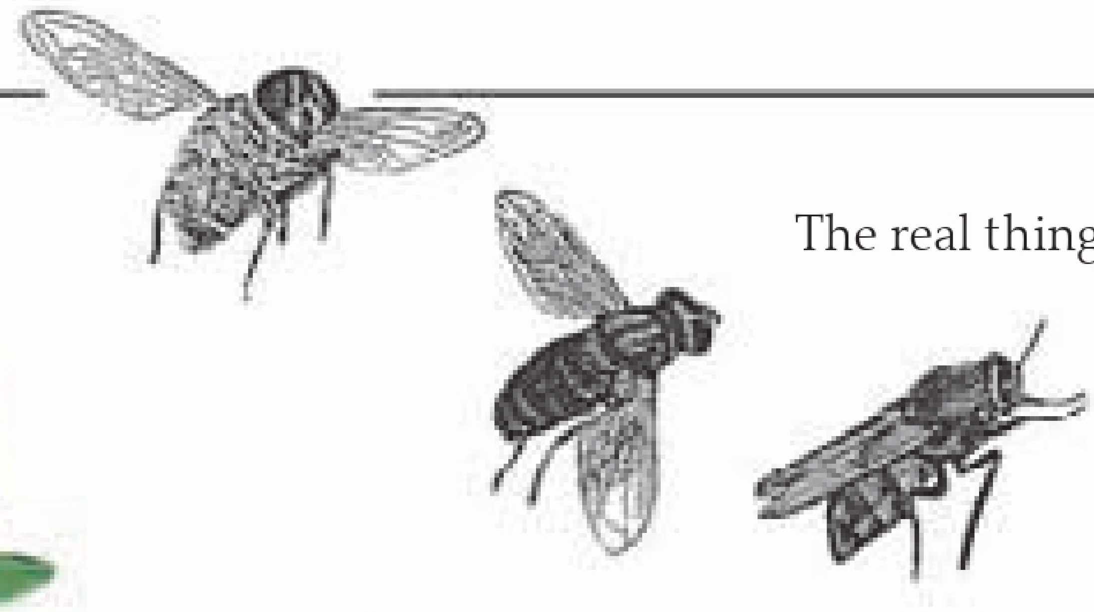


THE FLORAL FEEDING STATION
Honeyguides (p. 12) on the flower guide the bee to the nectar. As the bees feed on the nectar, they also collect pollen in special baskets on their legs so that it can be carried back to the hive.

OPENING UP
The flower of the common toadflax is pollinated by bumblebees. When a visiting bee arrives, the throat of the flower is tightly closed. To reach the nectar at the back of the flower, the bee must open up the flower by pushing forward.

CLIMBING IN
As the bumblebee climbs over the hump that seals the flower's throat and crawls inside in search of the nectar, it brushes against the anthers inside the top of the flower. These dust its back with pollen.

FEEDING TIME
As the bee feeds on the flower's nectar, any pollen it is already carrying is transferred from its back to the stigma, and the flower is pollinated.



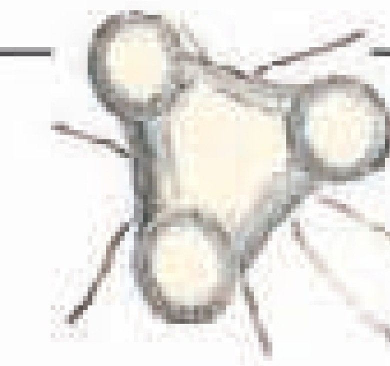
The real thing!

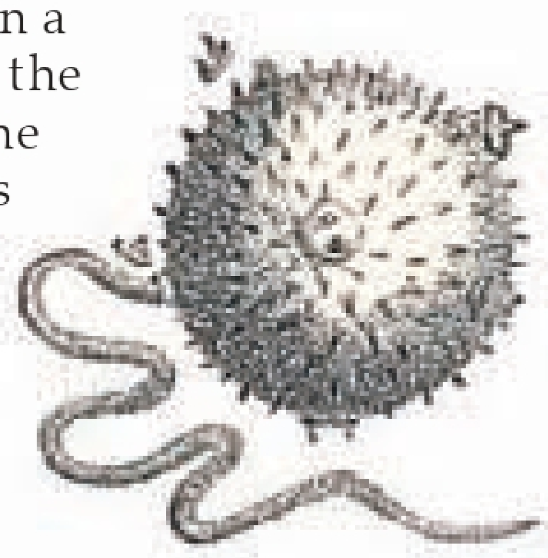
Flowers of the fly orchid

Female impersonators

Some orchids use a clever trick to ensure that they are pollinated. Each flower looks and smells like a female fly, wasp, or bee. The impersonation is so convincing that the male tries to mate with the flower. When this happens, pollen sticks to the bee's body, and when the insect eventually flies off, the pollen is carried to the next flower.

POLLEN GRAINS
Although the largest pollen grains measure only about $\frac{1}{120}$ in (0.2 mm) across, they have extraordinarily intricate shapes. When a pollen grain lands on the stigma of a plant of the same species, it grows a fine tube down the style (p. 17) until it reaches the ovule, or female cell (pp. 26–27).





Pollen grains magnified many times to show the variety of shapes

Long proboscis

Short proboscis

BUTTERFLY POLLINATION
Butterflies are also important pollinators but, unlike bees, they do not feed on the pollen and so do not actively collect it. Instead, when they land on a flower to feed on the nectar, pollen from the anthers sticks to their bodies, ready to be carried to the next flower. Because butterflies have a highly developed sense of smell, butterfly-pollinated flowers are often scented. Many flower in late summer, when butterflies are most abundant.

DRINKING STRAWS
Butterflies and moths suck up nectar through the proboscis, which is hollow like a drinking straw. The proboscis may vary in length from a fraction of a millimeter to 1 ft (30 cm). When resting, it is coiled up under the butterfly's head.

Proboscis sucks up nectar

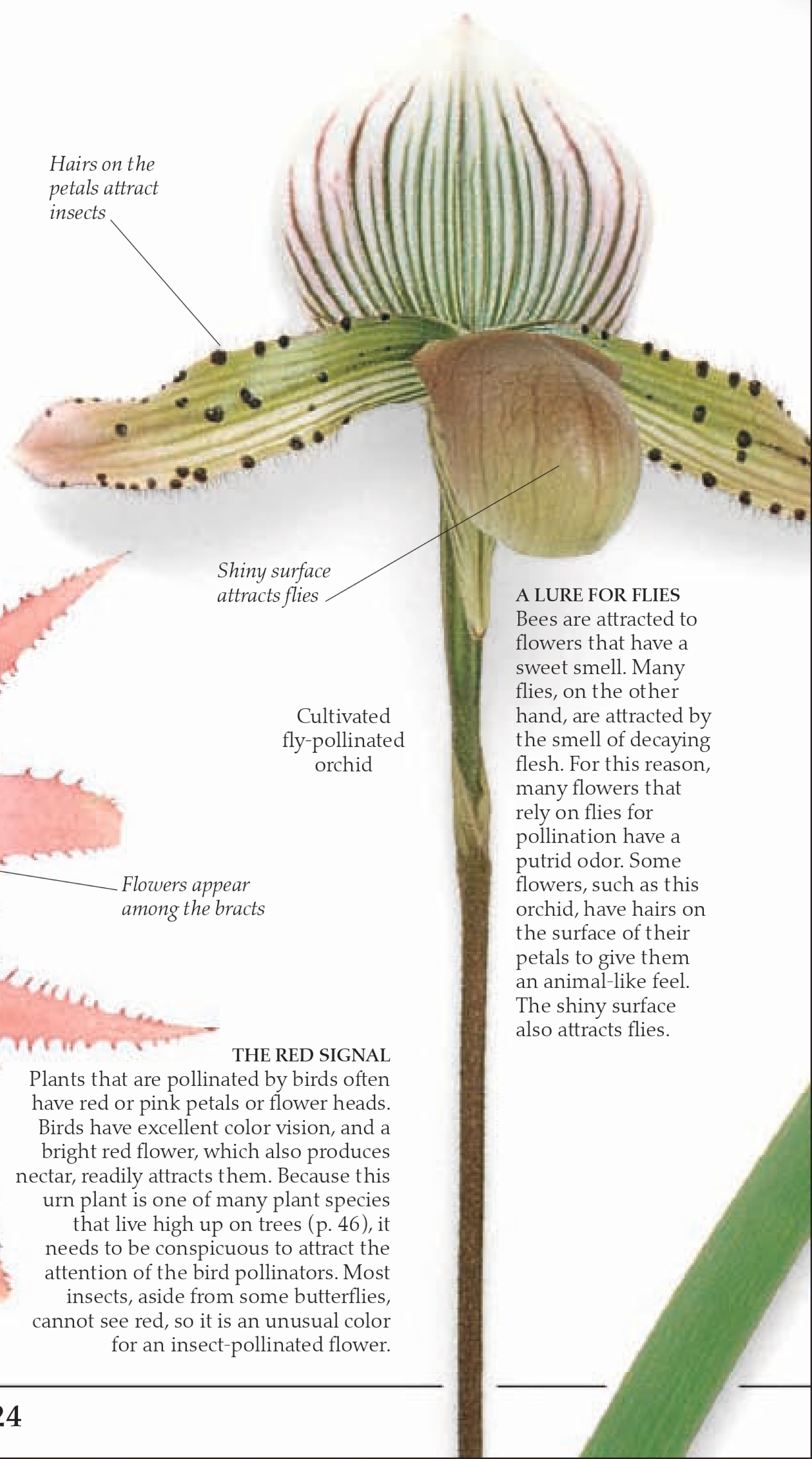
Pollen from anthers sticks to the butterfly's body

Marjoram

DISAPPEARING TRICK
One rare orchid, from Western Australia, spends almost all of its life under ground. It has no leaves, and its flowers grow in cup-shaped clusters that open just level with the surface. The flowers attract termites, gnats, and other insects that help to spread their pollen. After producing their seeds, the flowers wither away, and the orchid disappears below ground once again.

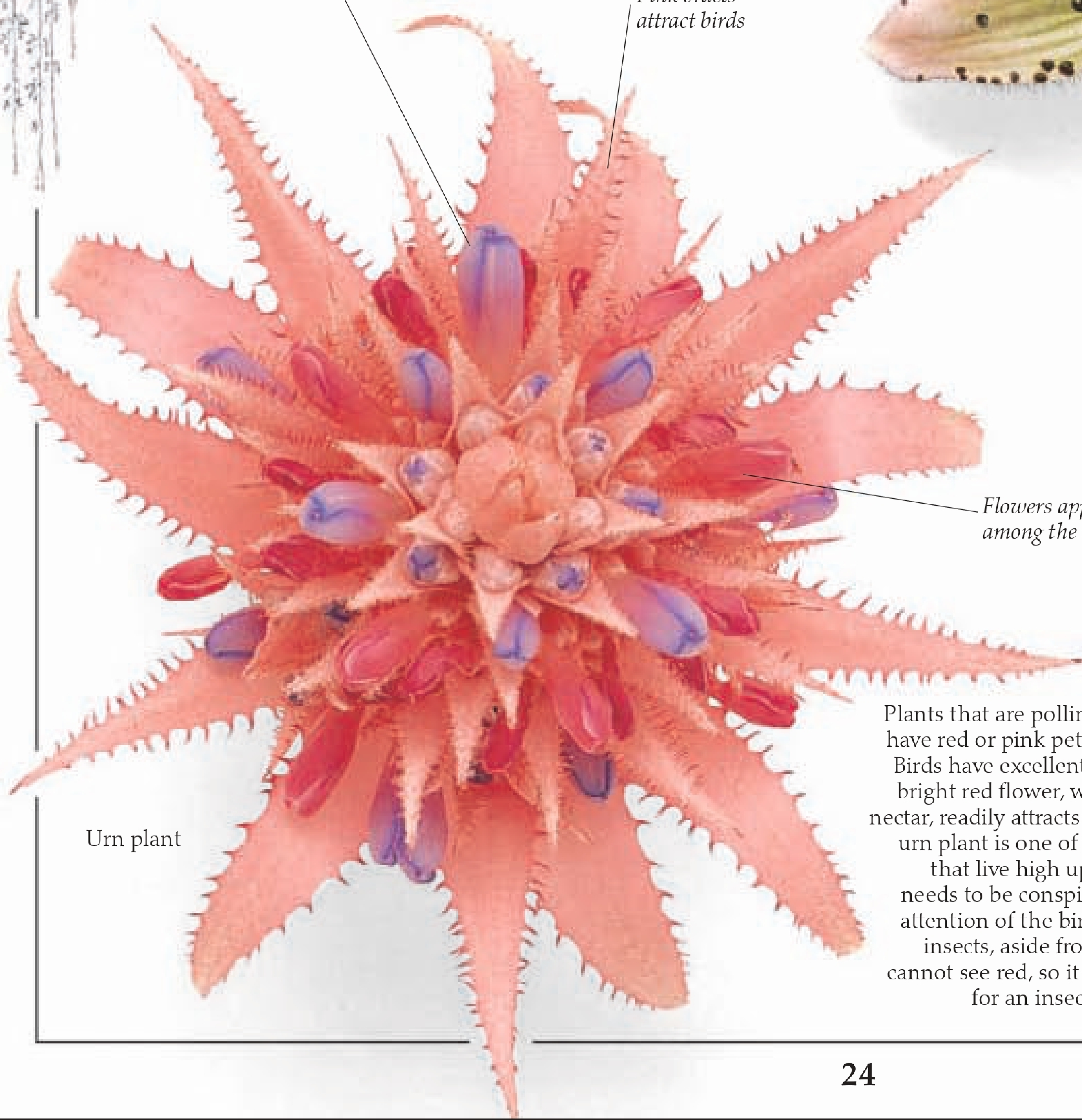
Strange pollinators

Many flowers are pollinated by bees and butterflies (p. 22), but some plant species depend on quite different creatures for pollination. Some are pollinated by the kind of flies that are attracted by the smell of decay. Others rely on birds, which are attracted to the flowers by bright colors and the sweet smell of nectar. Many plants are highly adapted for specific pollinators. The list of these species includes not only insects and birds, but also bats, mice, possums, and even slugs.



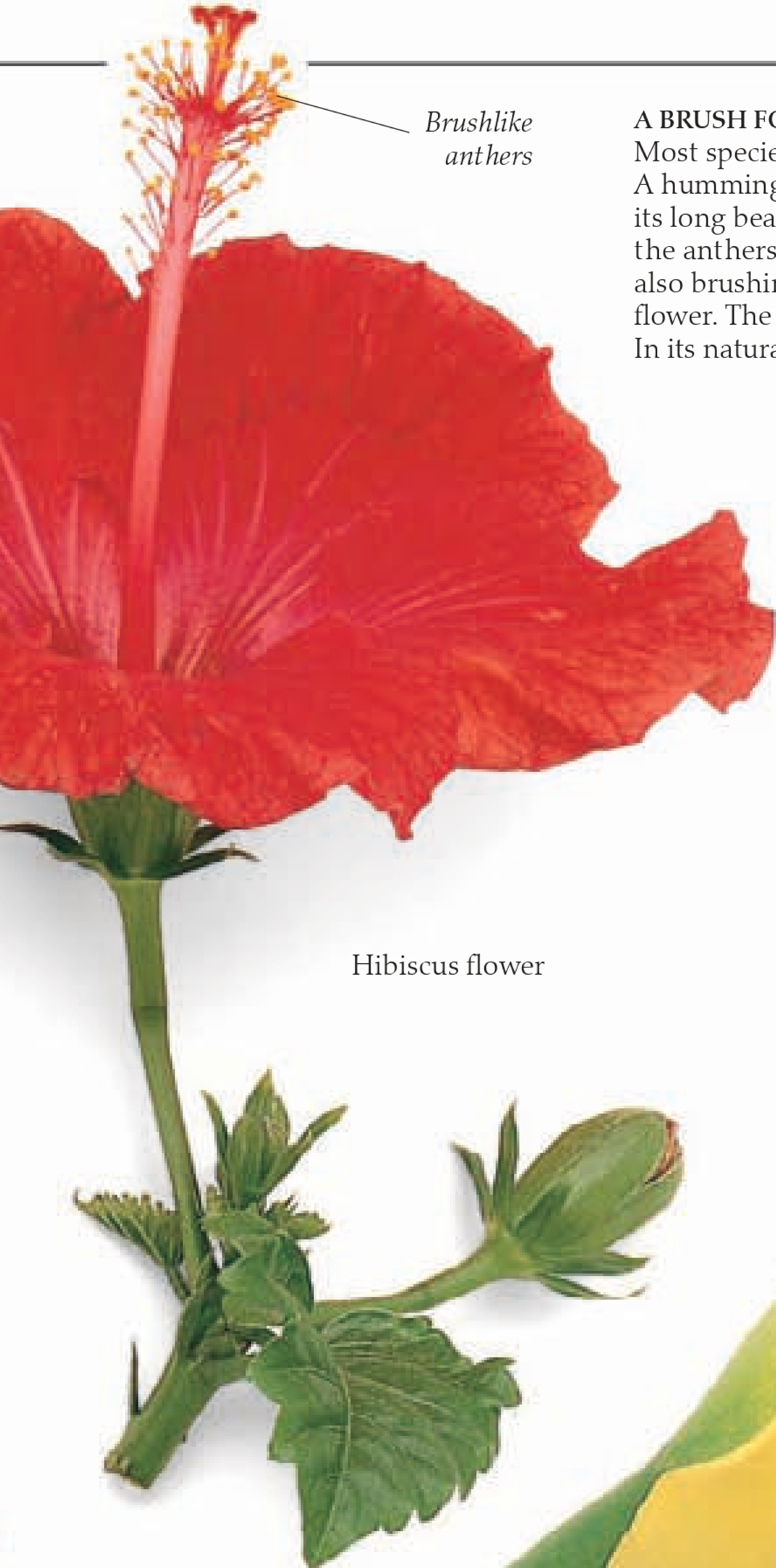
Cultivated fly-pollinated orchid

A LURE FOR FLIES
Bees are attracted to flowers that have a sweet smell. Many flies, on the other hand, are attracted by the smell of decaying flesh. For this reason, many flowers that rely on flies for pollination have a putrid odor. Some flowers, such as this orchid, have hairs on the surface of their petals to give them an animal-like feel. The shiny surface also attracts flies.



Urn plant

THE RED SIGNAL
Plants that are pollinated by birds often have red or pink petals or flower heads. Birds have excellent color vision, and a bright red flower, which also produces nectar, readily attracts them. Because this urn plant is one of many plant species that live high up on trees (p. 46), it needs to be conspicuous to attract the attention of the bird pollinators. Most insects, aside from some butterflies, cannot see red, so it is an unusual color for an insect-pollinated flower.



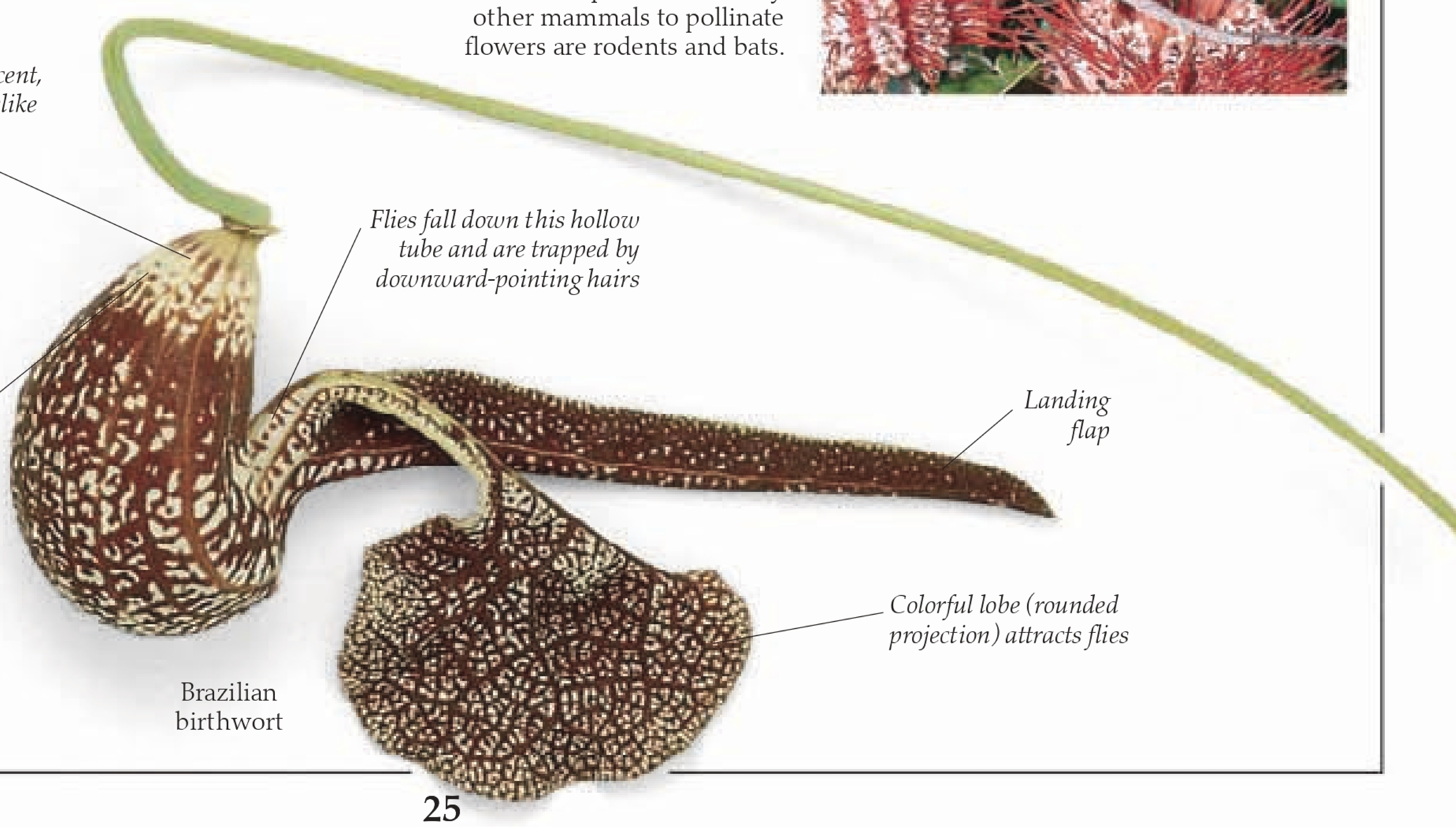
Hibiscus flower

A BRUSH FOR BIRDS
Most species of hibiscus are pollinated by hummingbirds. A hummingbird hovers in front of the flower and inserts its long beak deep inside to reach the nectar. As it feeds, the anthers brush pollen on to its head, while the stigma, also brushing its head, collects pollen from another flower. The flower shown here is in an upright position. In its natural state it would normally be horizontal.

BIZARRE BEAUTY
The yellow calla lily is pollinated by insects called fungus gnats. Its separate male and female flowers grow on a spadix, or central spike, and are enveloped by a bright yellow leaflike hood called a spathe. The insects, carrying pollen from the male flowers of other plants, crawl to the base of the spathe, where they become trapped by downward-pointing hairs. As they move around, they pollinate the female flowers. The hairs then wither, and as the insects crawl out they are dusted with pollen from the mature male flowers, ready to move on to the next plant.

Yellow calla lily

POSSUM POLLINATION
The Australian honey possum is a tiny marsupial that lives entirely on the pollen and nectar of flowers like this banksia. It collects its unusual food with its long snout and brushlike tongue. Aside from the possum, the only other mammals to pollinate flowers are rodents and bats.



Brazilian birthwort

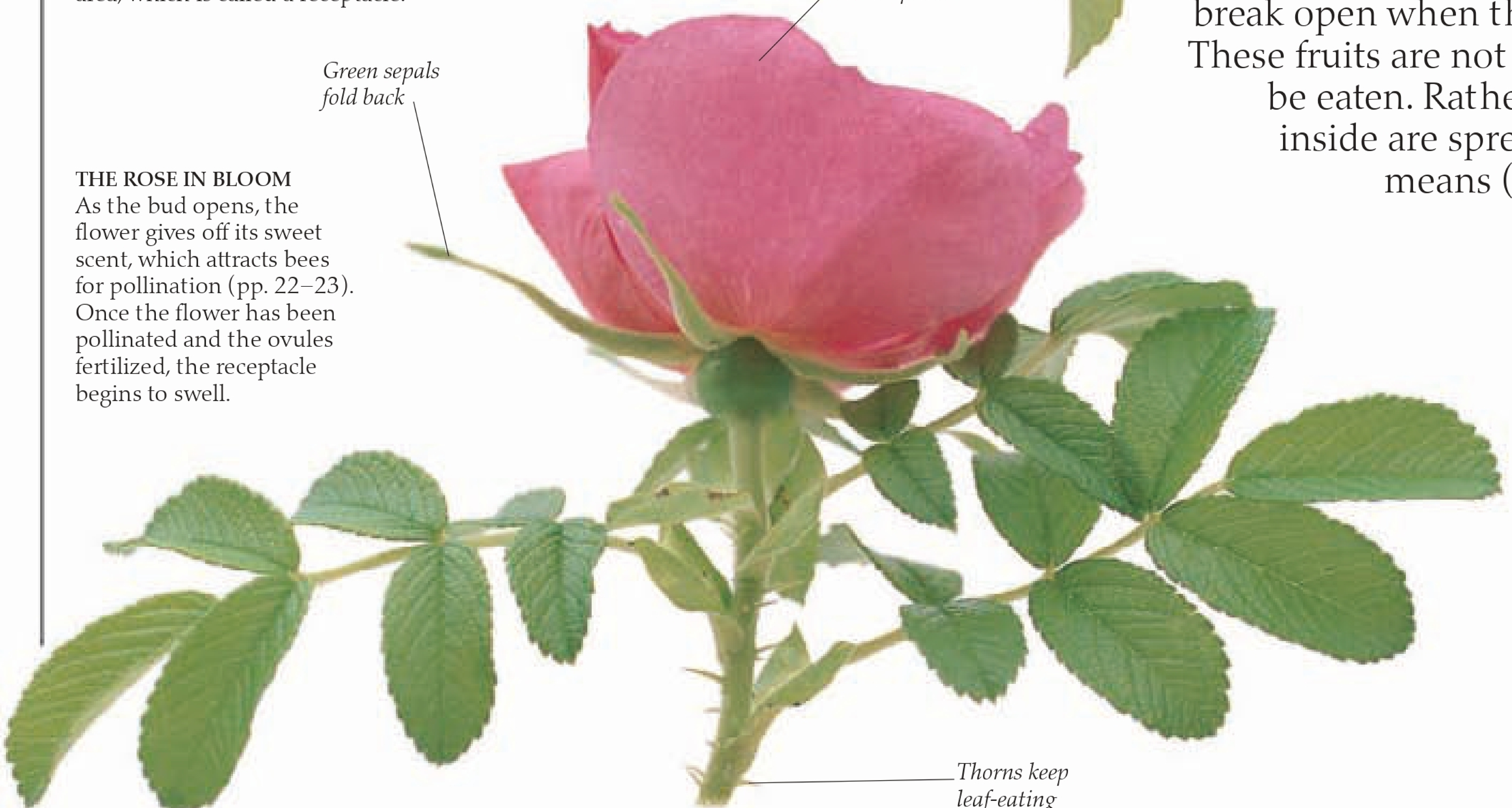
TAKING PRISONERS
This weirdly shaped flower is produced by a South American creeper. It lures flies by its smell of rotting fish. The flies enter the flower and are imprisoned within it overnight. When the flower begins to wither, the flies—now covered in pollen—can escape.

From flower to fruit

Plants grow flowers for an all-important task: to make seeds and spread them to new places. Some flowers make just one seed, while others can make millions. But no matter how many they make, the steps they follow are usually the same. For most flowers, the first step is pollination (pp. 22–23). This transfers tiny male pollen grains from flower to flower. If a pollen grain lands on the right kind of flower, step two can begin. The pollen grain comes to life and grows a microscopic tube down through the female part of the flower. Here, it searches out a female cell, or ovule. Once the pollen grain has found an ovule, its male cells travel down the tube and into the ovule to fertilize it. The pollen grain has now done its work, and the fertilized ovule starts to turn into a seed. Meanwhile, step three gets under way. The flower—now without its petals—begins to turn into a fruit. A fruit is something that helps the seeds to spread. Some plants produce soft, juicy fruits that attract animals looking for a meal. Animals eat the fruit, and they scatter the seeds as they feed. Many more plants produce dry, hard fruits that break open when they are ripe. These fruits are not designed to be eaten. Rather, the seeds inside are spread by other means (pp. 28–29).

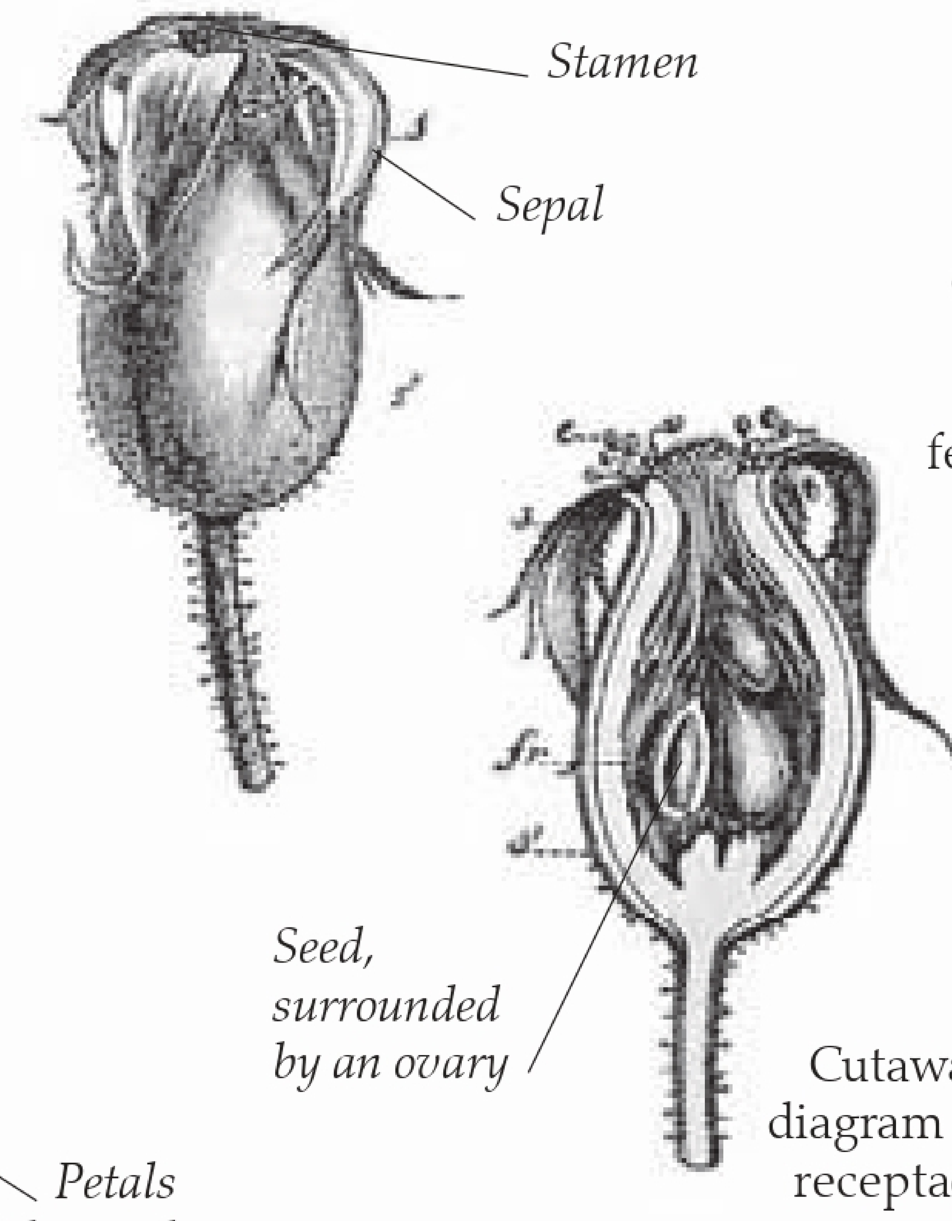
WINTER FEAST
Fruits are an important source of winter food for many animals. Here, a redwing feasts on fallen apples and may help to spread the apples' seeds.

EARLY DAYS
Even before the rose comes into flower, the beginnings of the rose hip can be seen clearly. The top of the stem, to which the flower parts are attached, is swollen and globular, as this bud shows. The flower's female parts, the ovaries and ovules, are inside this swollen area, which is called a receptacle.



THE ROSE IN BLOOM
As the bud opens, the flower gives off its sweet scent, which attracts bees for pollination (pp. 22–23). Once the flower has been pollinated and the ovules fertilized, the receptacle begins to swell.

BEGINNING OF THE END
The moment of fertilization is a turning point for the flower, and it begins its slow metamorphosis into a fruit. The petals are no longer needed to attract pollinating bees, so they wither and fall off.



Cutaway diagram of a receptacle

INSIDE STORY
Inside the receptacle, there are a great many ovaries. Each contains an ovule, which requires its own pollen grain for fertilization. The fertilized ovule develops into a seed. These seeds are enveloped in a thin yet tough coat and are known in botanical terms as achenes. The rose hip contains many of these small achenes.

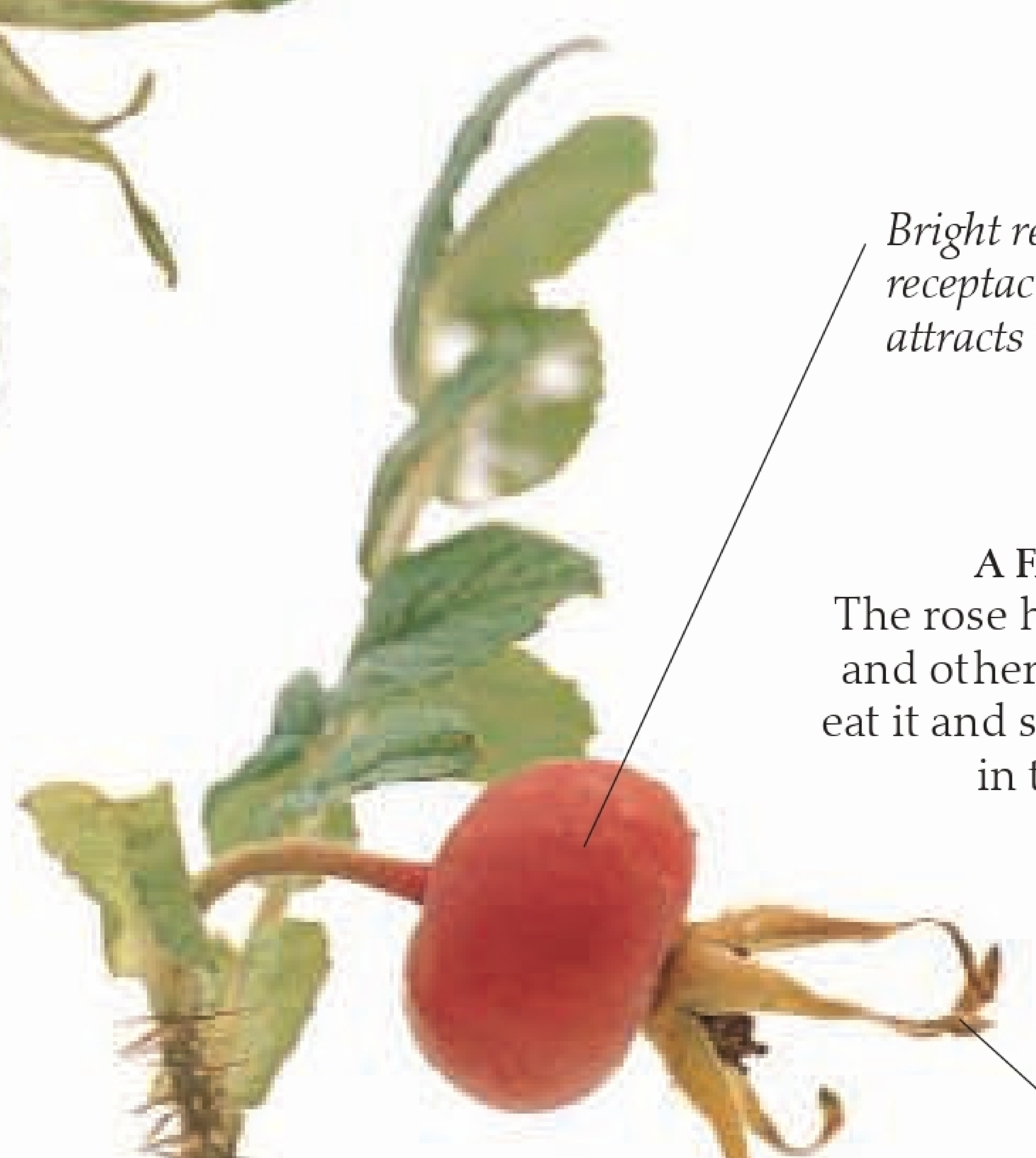
NATURAL CHEATS
Rose seeds are packed with nutrients to give the seedlings a good start in life. Some birds cheat the plant by eating the seeds, cracking them open to get at the food stores inside. Greenfinches do this, spurning the rose hip itself, which they leave hanging in tatters from the plant. The greenfinch gets a good meal, but in so doing it destroys the seeds rather than disperses them.

THE ROSE HIP
As the fertilized ovules develop into seeds called achenes, the receptacle swells and turns red. When ripe, it is called a rose hip.

USEFUL FRUITS
The achenes of the rose hip are covered in short, brittle hairs. A medicinal syrup made from rose hips is often given to babies and young children. Rose hips contain vitamin C, which helps protect against colds.

Cross-section of a ripe receptacle

PRECIOUS CARGO
The rose hip is brightly colored, attracting birds to eat it. The achenes inside the receptacle have tough skins. With luck, they will pass through the bird's digestive tract unharmed.



A FAIR EXCHANGE
The rose hip attracts birds and other animals, which eat it and spread the seeds in their droppings.

How seeds are spread

Agrimony

Fruits have hooks

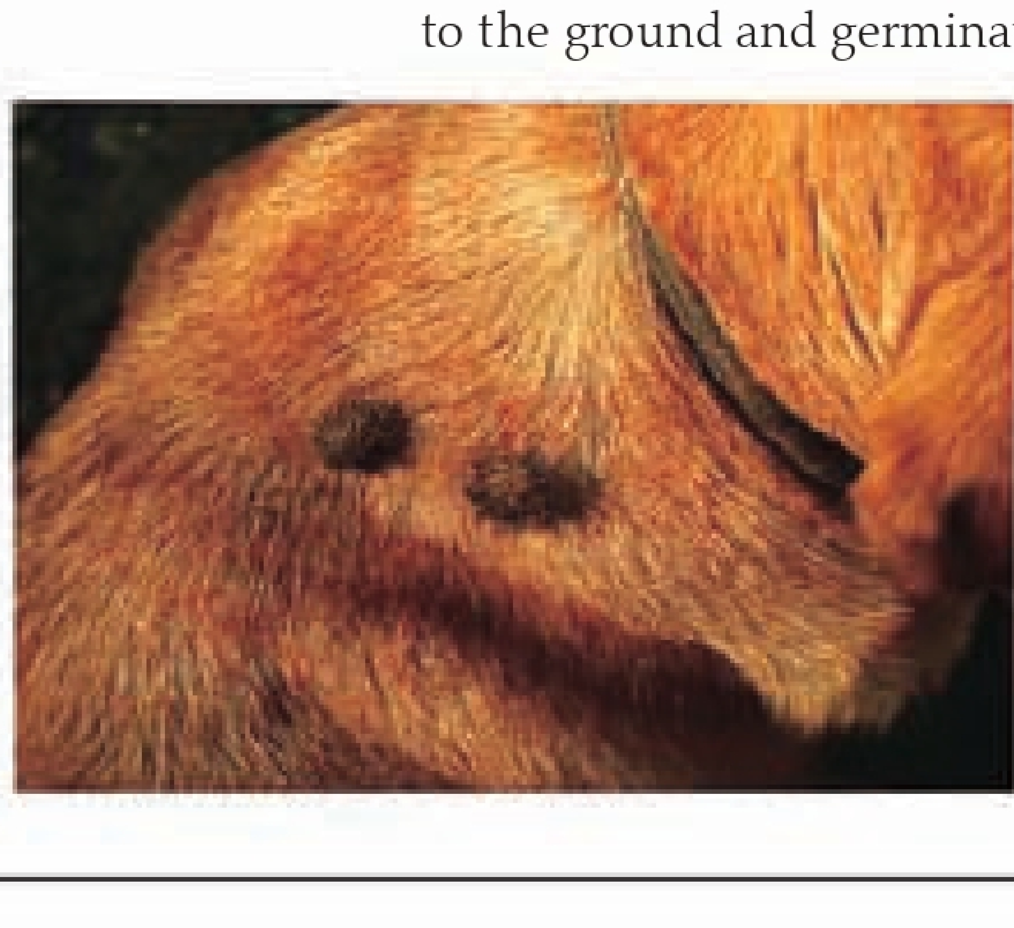
AS ALL GARDENERS KNOW, a patch of bare soil never stays bare for long. Within days, seedlings start to spring up, and if the conditions are right, they eventually cover the ground. Even if the soil is sterilized by heating, so that all the seeds are killed, more somehow arrive and germinate. Plants have evolved some very effective ways of spreading their seeds. In certain plants, exploding seed pods fling the seeds into the air. Others have flying or floating seeds or fruits that are carried far and wide by the wind and by water currents. Animals also play their part. Many plants have fruits with hooks that stick to fur. The seeds of some species develop inside tasty berries. The berries are eaten by animals and birds, but the seeds pass through the digestive system of these creatures unharmed and fall to the ground, where they germinate.

Each fruit has many tiny hooks

Lesser burdock

HITCHING A RIDE

The best way to find out which seeds are dispersed by animals is to go for a walk through rough grassland. You will probably return home with the fruits of a number of different plants stuck to your clothes. Known as burrs, these fruits have hooks and spines that cling to the fur and coats of passing animals. When the burrs are rubbed or scratched off, their seeds fall to the ground and germinate.

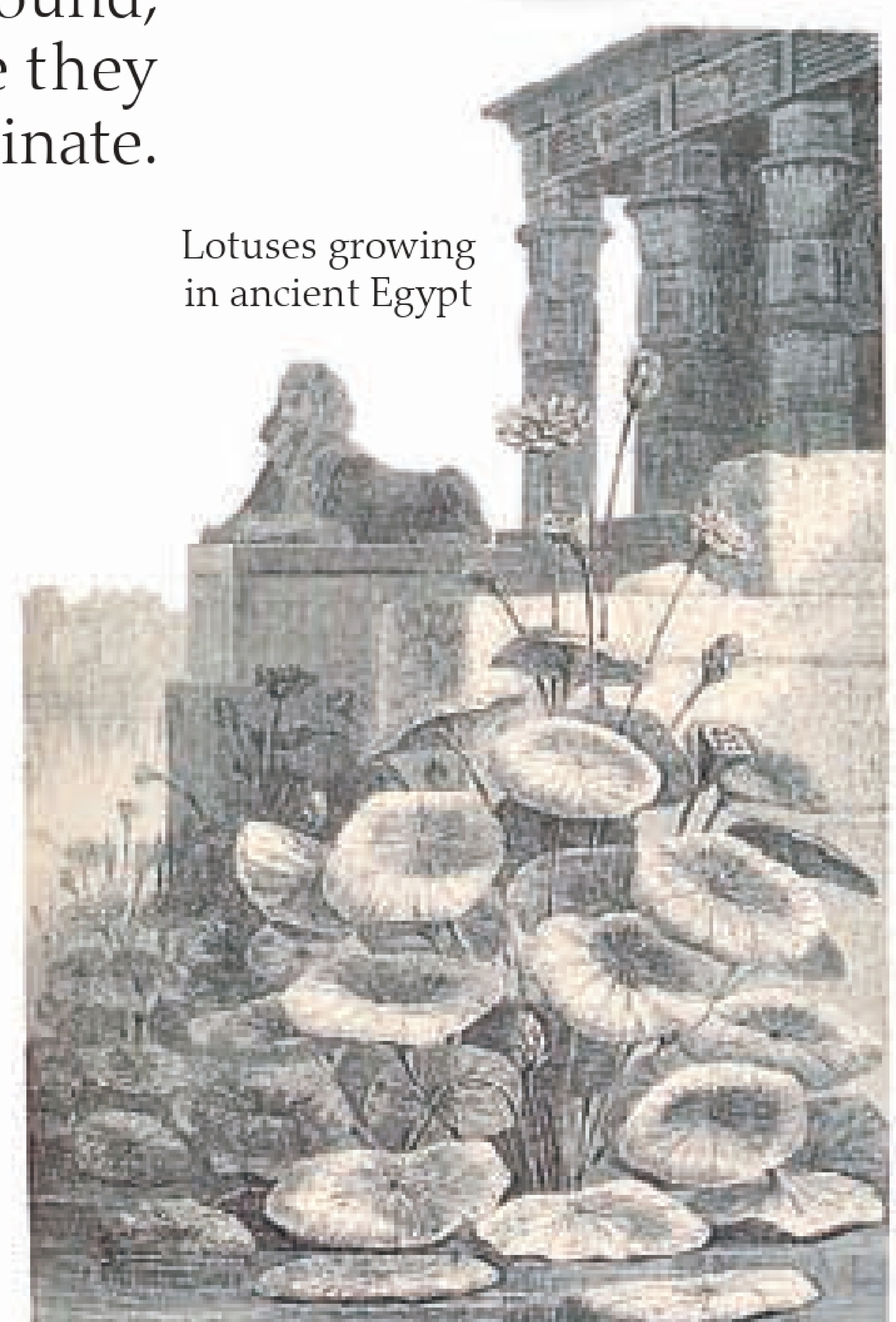


Burrs clinging to the fur on a dog's back

Lotus seed heads

Seed held in a cup

Dried lotus seed head, seen from above



Lotuses growing in ancient Egypt

WASHED AWAY

The lotus is a water plant that produces its seeds in a flattened head. When the seeds are ripe, they fall on to the water's surface and float away. Lotus seeds can live for an extraordinarily long time. Some have been known to germinate more than 200 years after they were shed.

OFF TO A FLYING START

Some plants disperse their seeds with natural catapults. These work by suddenly releasing the tension that builds up as the seed case grows: the seed case splits open, flinging the seeds in all directions. These catapults are triggered in a number of ways. Some, particularly the pods of pea-family plants such as vetches, burst open when the sun dries them. Others, such as the Himalayan balsam (p. 18), are triggered by movement, either by the wind blowing past or by an animal brushing against the plant.

Himalayan balsam flower

Closed seed pod

When touched, the seed case curls up suddenly and the seeds are flicked out

Unexploded seed pod

Seeds of meadow cranesbill are catapulted out

Pods of tufted vetch snap open when dry

Intact pod

BLOWING IN THE WIND

Seeds that are dispersed by the wind must be small and light if they are to be carried any distance by the breeze. When the wind shakes the seed heads of plants such as the opium poppy and columbine, the seeds are scattered just a short distance from the parent plant. When a thistle seed head catches the wind, its fruits (containing the seeds) can be swept high into the air, and be carried much farther.

Tiny, light seeds

Columbine

Seeds are sprinkled

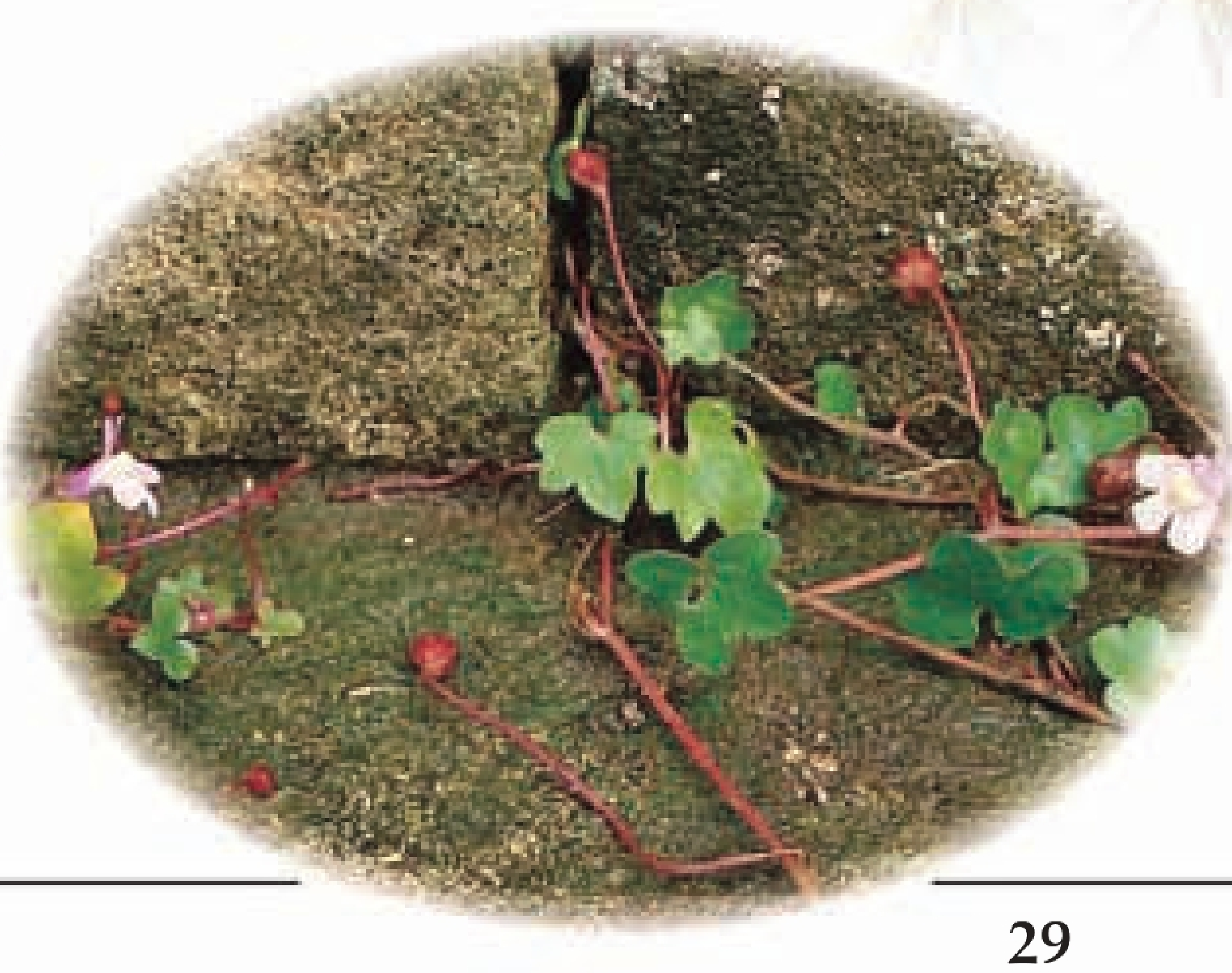
Opium poppy

Fruits have parachutes so they can be carried by the wind

Creeping thistle

SHUNNING THE LIGHT

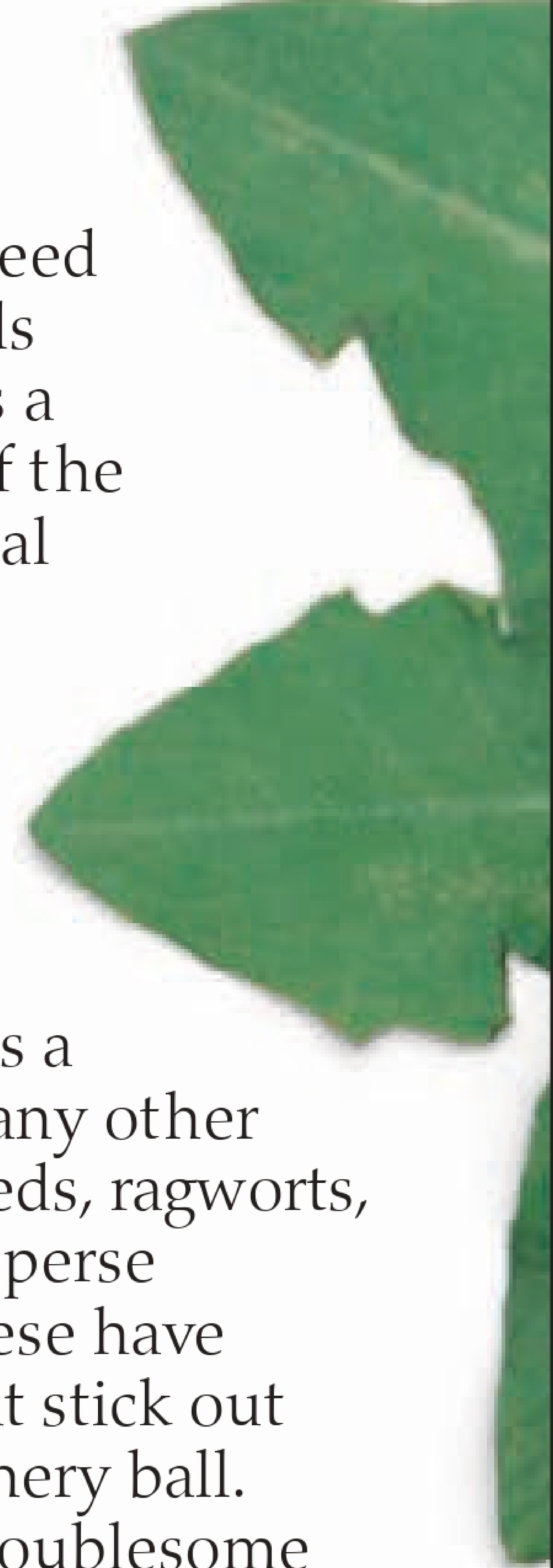
The ivy-leaved toad-flax grows on walls and rock faces. As its seeds ripen, the stems carrying the seed heads grow away from the light, pushing the seeds into cracks and crevices. This ensures that they have somewhere suitable to germinate.

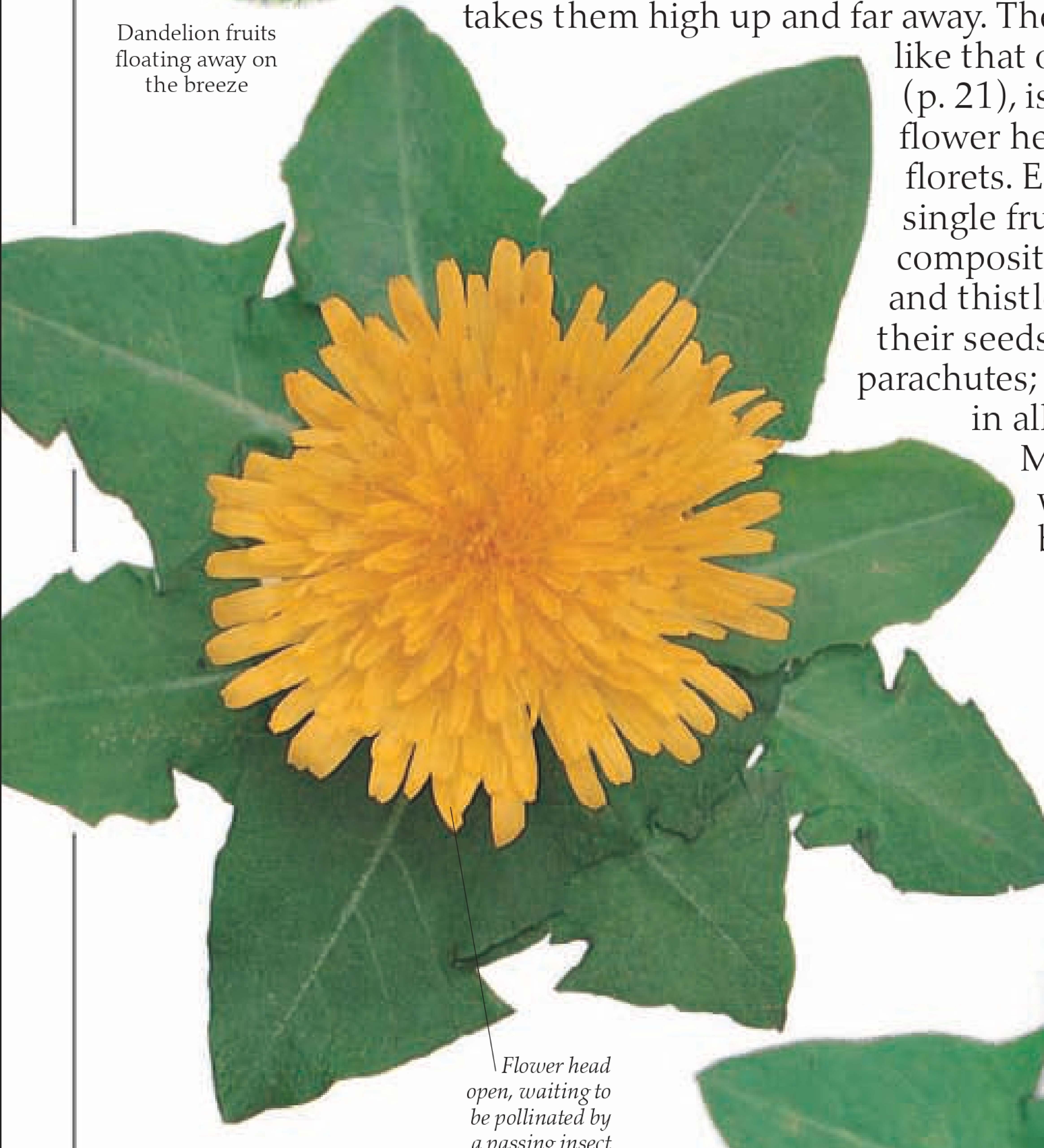


Borne on the wind

Dandelion fruits floating away on the breeze

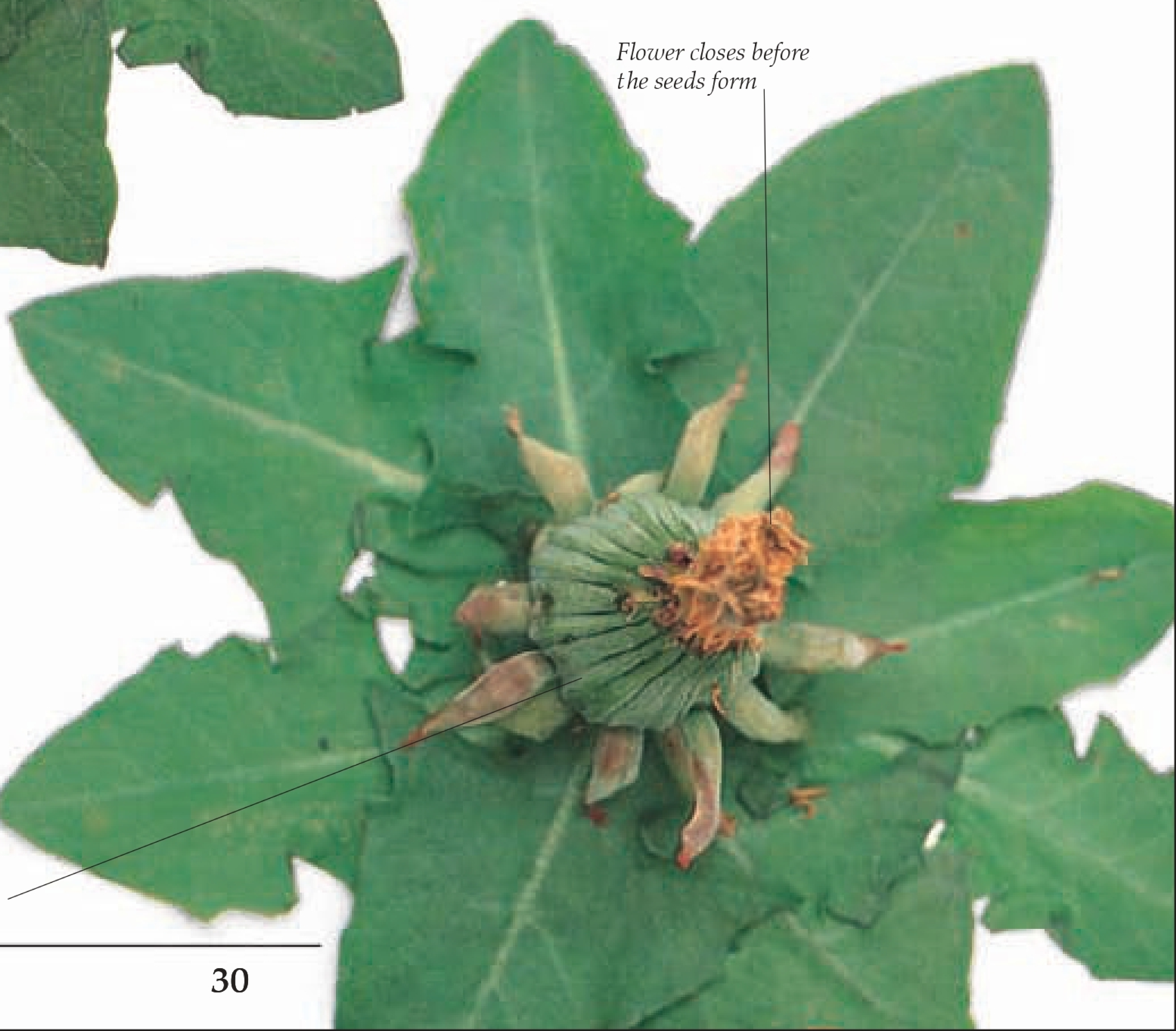
According to tradition, if you blow on a dandelion's seed head, the number of puffs needed to blow away all the seeds will tell you the time of day. Whether or not this is true, it is a custom that certainly helps the plant to spread. The seeds of the dandelion are encased in tiny fruits and have their own special feathery parachutes to help them float through the air. If you blow on them, you may be starting the seeds on a journey that takes them high up and far away. The dandelion's flower, like that of the sunflower (p. 21), is actually a composite flower head made up of many tiny florets. Each of the florets produces a single fruit. Like the dandelion, many other composite plants, such as hawkweeds, ragworts, and thistles, rely on the wind to disperse their seeds. The fruits of some of these have parachutes; others have fine hairs that stick out in all directions to form a feathery ball. Many of these plants are troublesome weeds because they quickly colonize bare soil in gardens and on farmland.





Flower head open, waiting to be pollinated by a passing insect

1 OPENING TIME
The dandelion's flower opens in the morning and closes in the afternoon or when it rains. The plant's name comes from the French *dent de lion*, meaning lion's tooth, which describes the jagged edges of the leaves.



Flower closes before the seeds form

2 THE SEEDS START TO FORM
After opening and closing for a number of days, during which time it may be pollinated, the flower finally closes, and seed formation begins. Gradually, the yellow petals wither away, and the pappus, which is the name given to the small circle of hairs attached to the top of each fruit, starts to grow longer. This is the beginning of the parachute.

Bracts protect the developing seed head

3 OPENING OUT

The seed head begins to open only when the weather is dry. At first, the parachutes are squashed together, but as the bracts around the edge of the seed head fold back, the parachutes begin to expand.

4 READY TO GO

If the air is still, the fruits may spend several days attached to the seed head. This is a dangerous time for them, because seed-eating birds such as goldfinches are likely to peck them off and eat them.

5 LIFTOFF

A slight breeze is all that is needed to lift the parachutes into the air. They may fall close by, but if there is enough updraft they can be carried for long distances. When a fruit lands, it no longer needs the parachute that has carried it on its journey, and this breaks off. Over the winter the seed sinks into the soil, waiting for the spring when it begins to germinate.

Spreading without seeds

THE PIGGYBACK PLANT
The piggyback plant has an unusual way of reproducing. Tiny new plantlets grow at the base of the older leaves and look as though they are having a piggyback ride.

PLANTS CAN REPRODUCE in two very different ways. In addition to reproducing by means of seeds, they can sometimes also turn small pieces of themselves into new plants. This is known as vegetative reproduction. When a plant reproduces in this way, the young plantlets are genetically identical to the parent. This is very different from reproduction with seeds, which produces seedlings that are all slightly different from their parents. Vegetative reproduction is very useful for farmers and gardeners. It allows them to multiply a plant that has attractive flowers or tasty fruit, knowing that each young plant will have exactly the characteristics they want. The world's oldest plants all grow by forming clumps—another form of vegetative reproduction. In the southwestern United States, there are clumps of creosote bushes up to 12,000 years old, which makes them twice as old as the oldest single trees. In Tasmania, Australia, some clumps of king's holly are more than 40,000 years old, and still growing strong.

CREEPING STEMS
Some plants, such as the creeping buttercup, spread by means of stolons, which are leafy stems that grow along the ground. When the stolons reach a certain length, a new, young plant develops from a bud at the leaf node (p. 9), and the stolon eventually withers away completely.

Chandelier plant

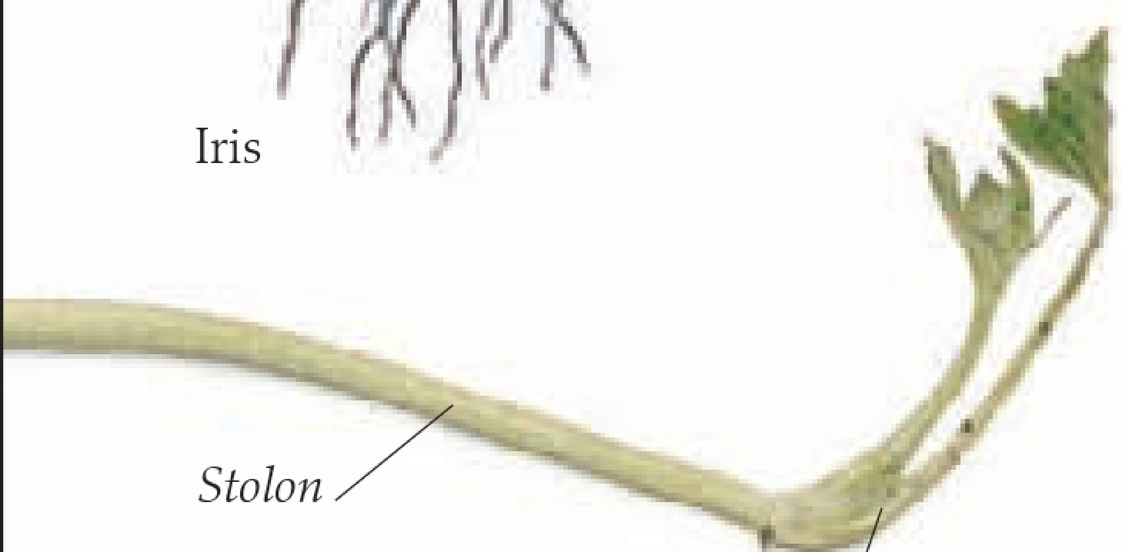
PLANTLETS AT LEAF TIPS
Kalanchoes are succulents (p. 53), many of which reproduce by developing tiny plantlets along the edges of their leaves. Others, like this chandelier plant, have them just at the tips. When a plantlet is mature, it falls off the parent plant and takes root in the soil beneath.

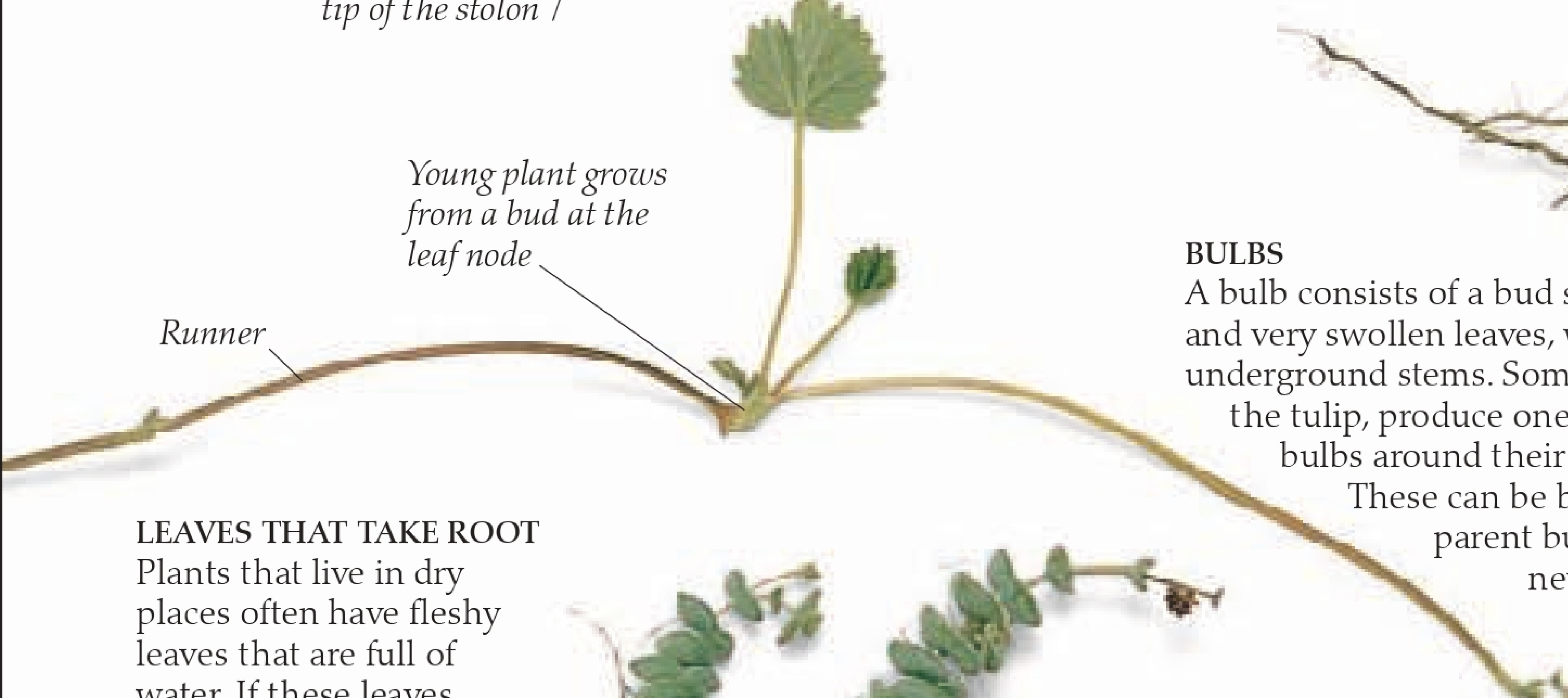
STRAWBERRY RUNNERS
After they have fruited, strawberry plants produce long stolons known as runners, which spread out over the ground. Strawberry growers wait until the young plants have rooted and then cut the runners. The new plants can be transplanted to make a new strawberry bed.

A MYTH EXPLODED
The famous tumbleweed of the North American prairies is uprooted by strong winds after it has flowered and is often blown far away from the place where it grew. The dead plant cannot put down roots once it comes to a halt, as is often supposed. Instead, it spreads by seeds. The plant scatters them as it tumbles along the ground.

RHIZOMES
A rhizome is a usually horizontal stem produced by a perennial plant, either under ground or on the surface. As the rhizome spreads, it occasionally divides, producing roots, stems, and leaves. The oldest part of the rhizome may die away so that these new shoots form separate plants.

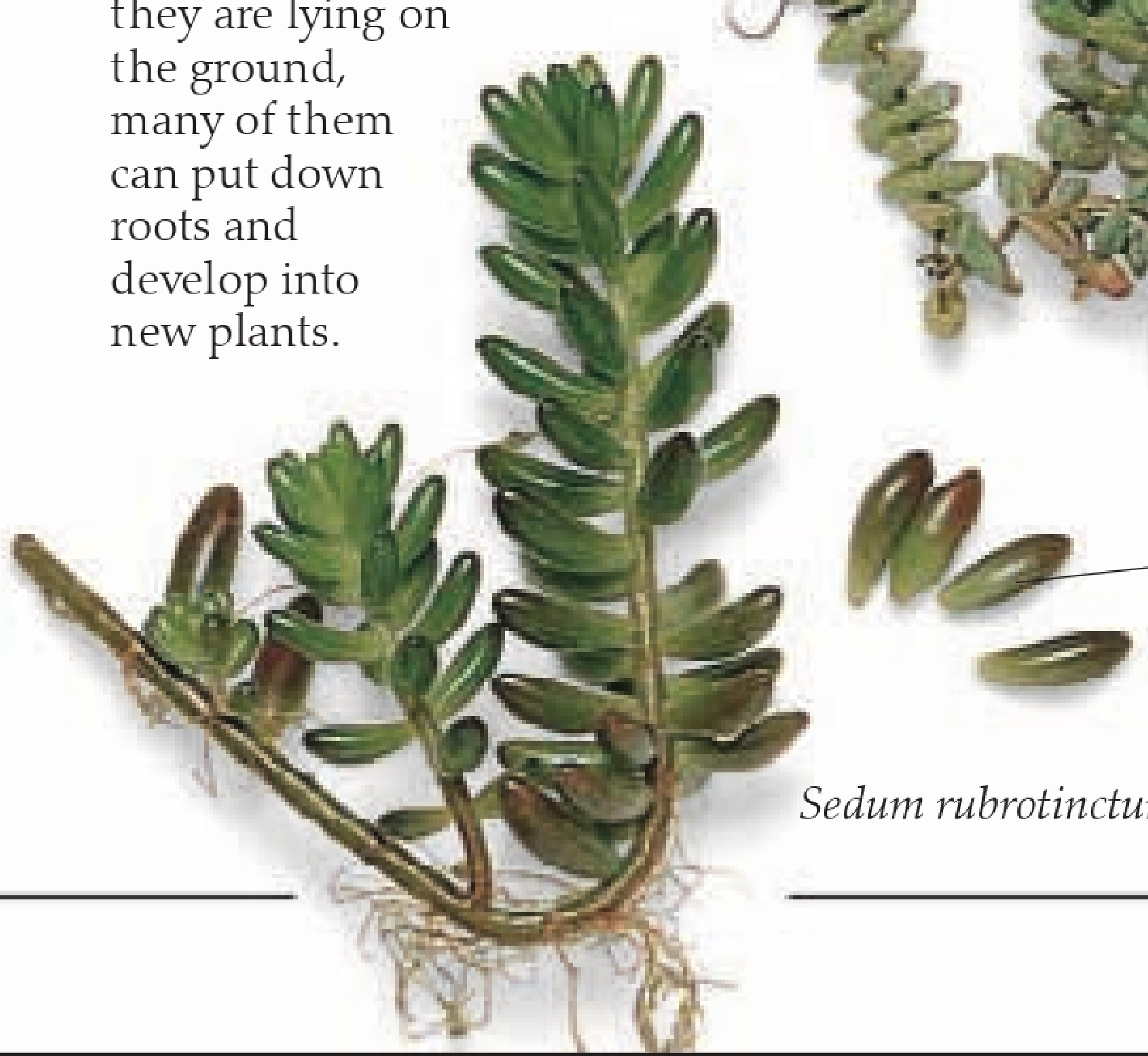
TUBERS
Tubers are swollen underground stems. They store food to produce new plants and also to help the parent plant to survive in adverse conditions. When gardeners and farmers lift tuber crops like potatoes, they have to be careful to dig up every one. If even part of the potato is left in the ground, it will sprout to produce a new plant the following spring.



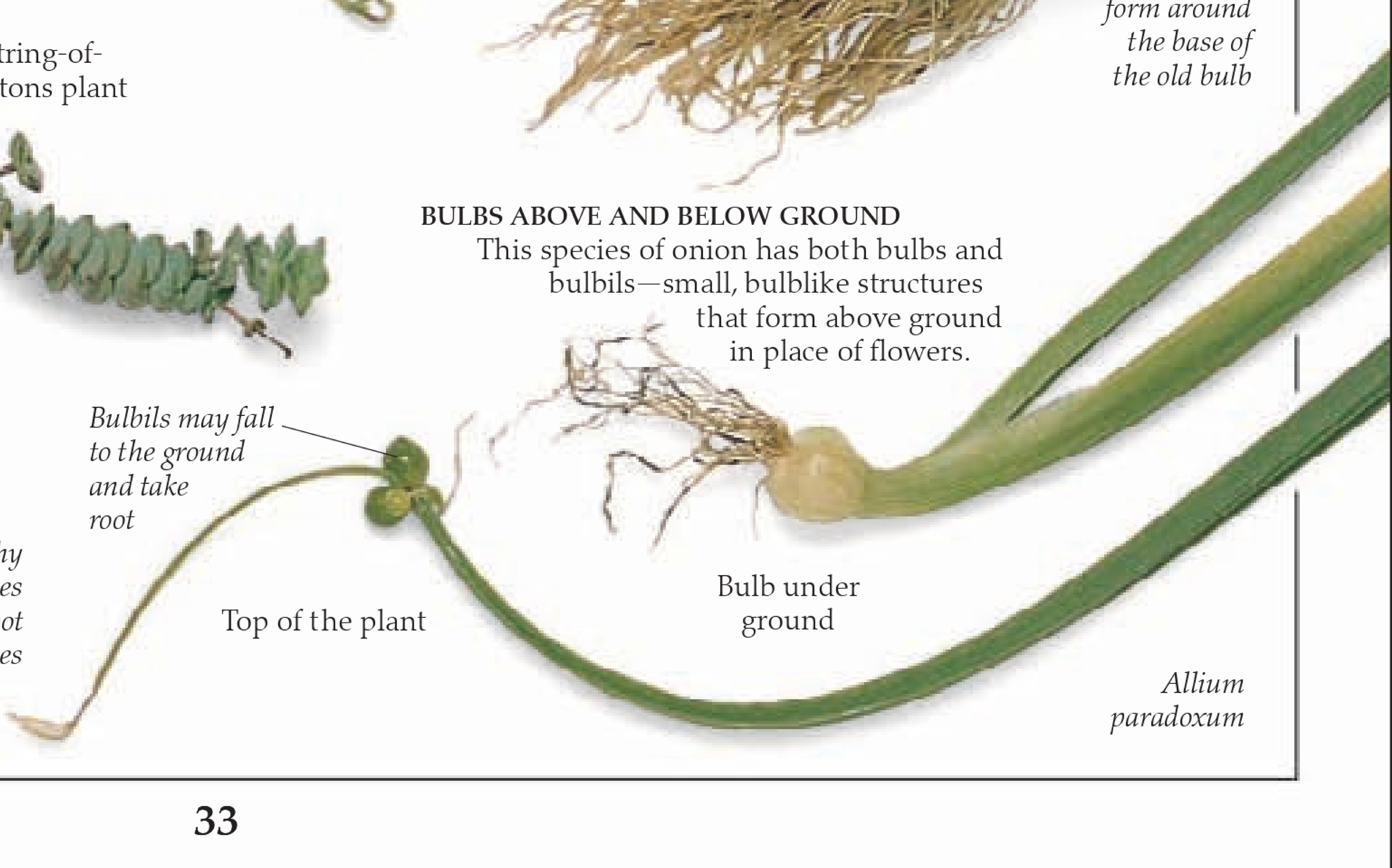


BULBS
A bulb consists of a bud surrounded by short and very swollen leaves, with flattened underground stems. Some bulbs, such as the tulip, produce one or more new bulbs around their base every year. These can be broken off the parent bulb to form new plants.

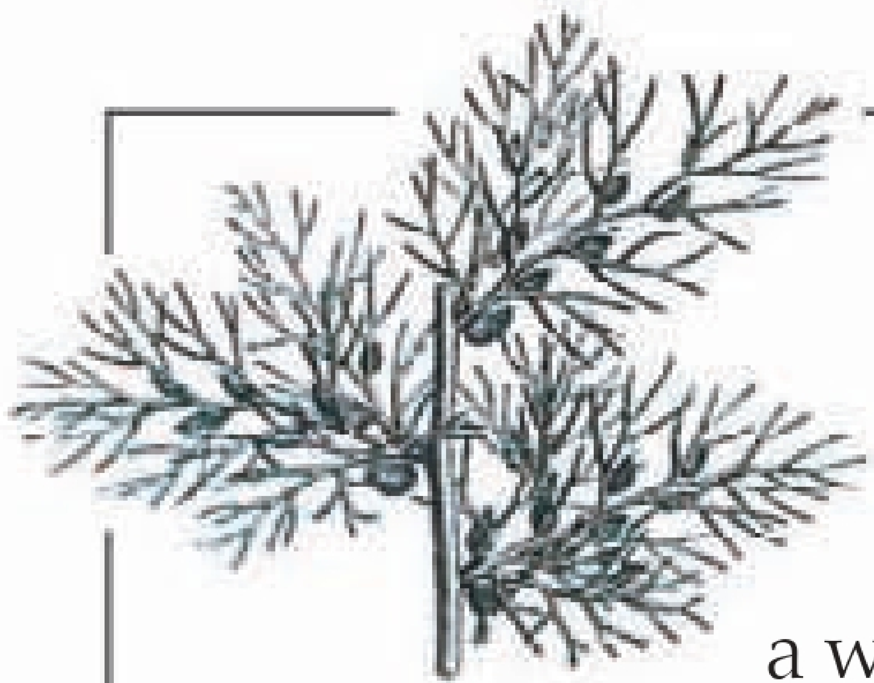
LEAVES THAT TAKE ROOT
Plants that live in dry places often have fleshy leaves that are full of water. If these leaves are broken off, they can survive for a long time, because they do not dry out as quickly as normal, thin leaves. While they are lying on the ground, many of them can put down roots and develop into new plants.



BULBS ABOVE AND BELOW GROUND
This species of onion has both bulbs and bulbils—small, bulblike structures that form above ground in place of flowers.



Living leaves



FEATHERY LEAVES
Water plants often have feathery leaves to allow the water to flow past without damaging them.

Leaves are so varied that botanists have invented a whole new language to describe their shapes and the way they are fixed to plants. One reason for all this variety is that each species of plant faces its own chalenges in harvesting sunlight (pp. 14–15). A plant living on the gloomy floor of a rain forest, for example, may need big leaves to catch enough light. A plant growing on top of a cliff has plenty of light, but it is lashed by strong winds, so it needs small, strong leaves if it is to survive. Some plants have more than one type of leaf. This is most marked in plants that start their lives under water but then flower above it. One example is the water crowfoot. Its submerged leaves are fine and feathery, to let water flow past without tearing them, while its upper leaves are flat and broad, so that they float on the surface.

CHANGING COLOR
The leaves of the herb Robert change from green to crimson as fall approaches, or in very dry weather.

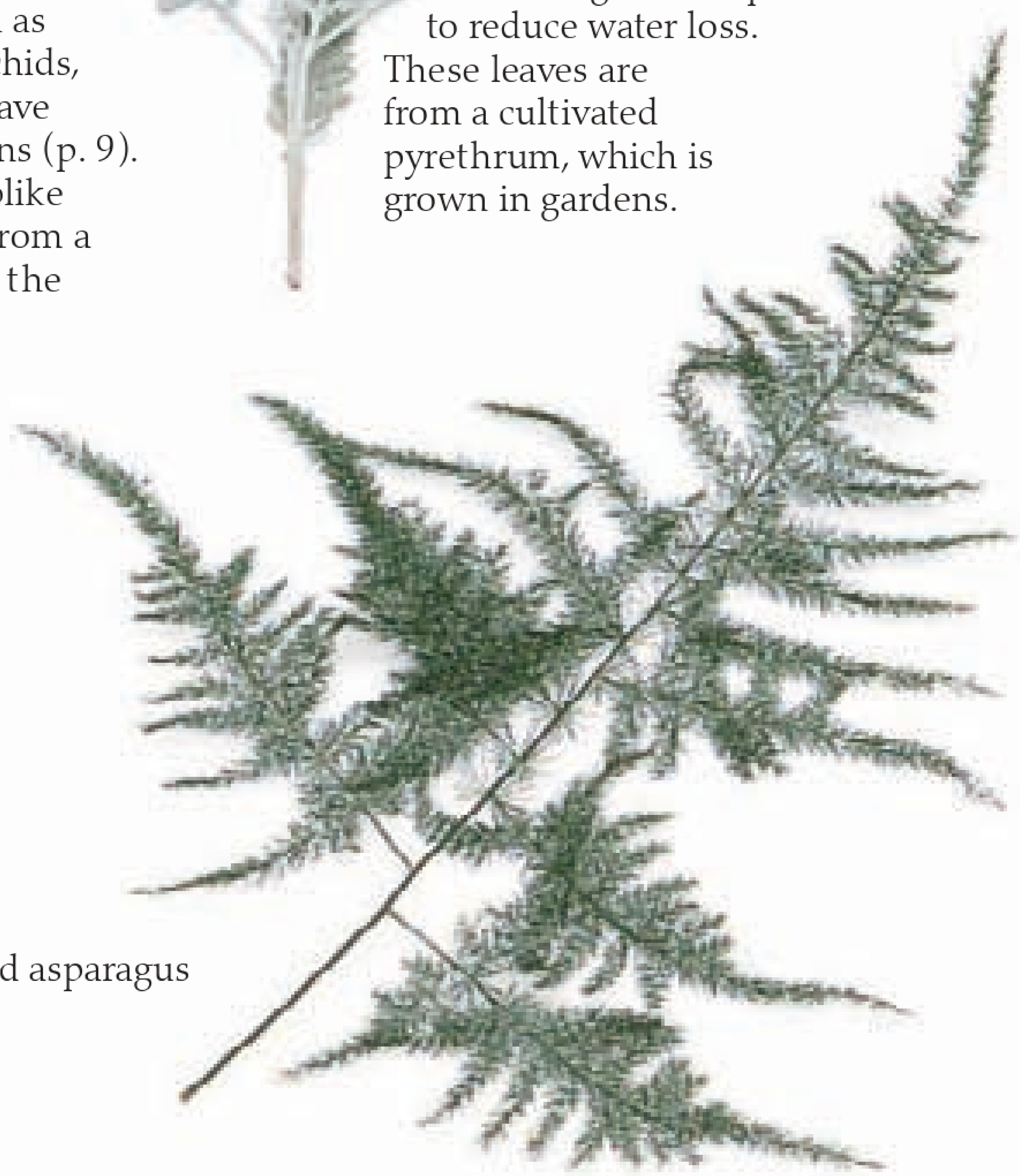
Older leaves

Young leaves

DIFFERENT SHAPES
This eucalyptus tree has leaves of two totally different shapes. The leaves of the young stems are round, like coins, and each one completely encircles the branch. The leaves on the older parts of the stems have stalks and are shaped like short straps.

PARALLEL VEINS
The leaves of plants such as grasses, orchids, and lilies have parallel veins (p. 9). These straplike leaves are from a member of the lily family.

FURRY LEAVES
Some leaves have a furlike covering that helps to reduce water loss. These leaves are from a cultivated pyrethrum, which is grown in gardens.



Wild asparagus

FACING THE WIND
Wild asparagus lives on windy coasts. Instead of true leaves, it has feathery, green, leaflike stems, called cladodes, which can withstand gales. Large, fleshy leaves would be torn to pieces.

Leaf supported by strong ribs

WATERSIDE GIANTS
Gunneras grow on riverbanks in tropical forests, but are sometimes found beside water in warmer parts of temperate countries. Their leaves can be enormous—as much as 6 ft (2 m) in diameter.

Underside of a section of a gunnera leaf

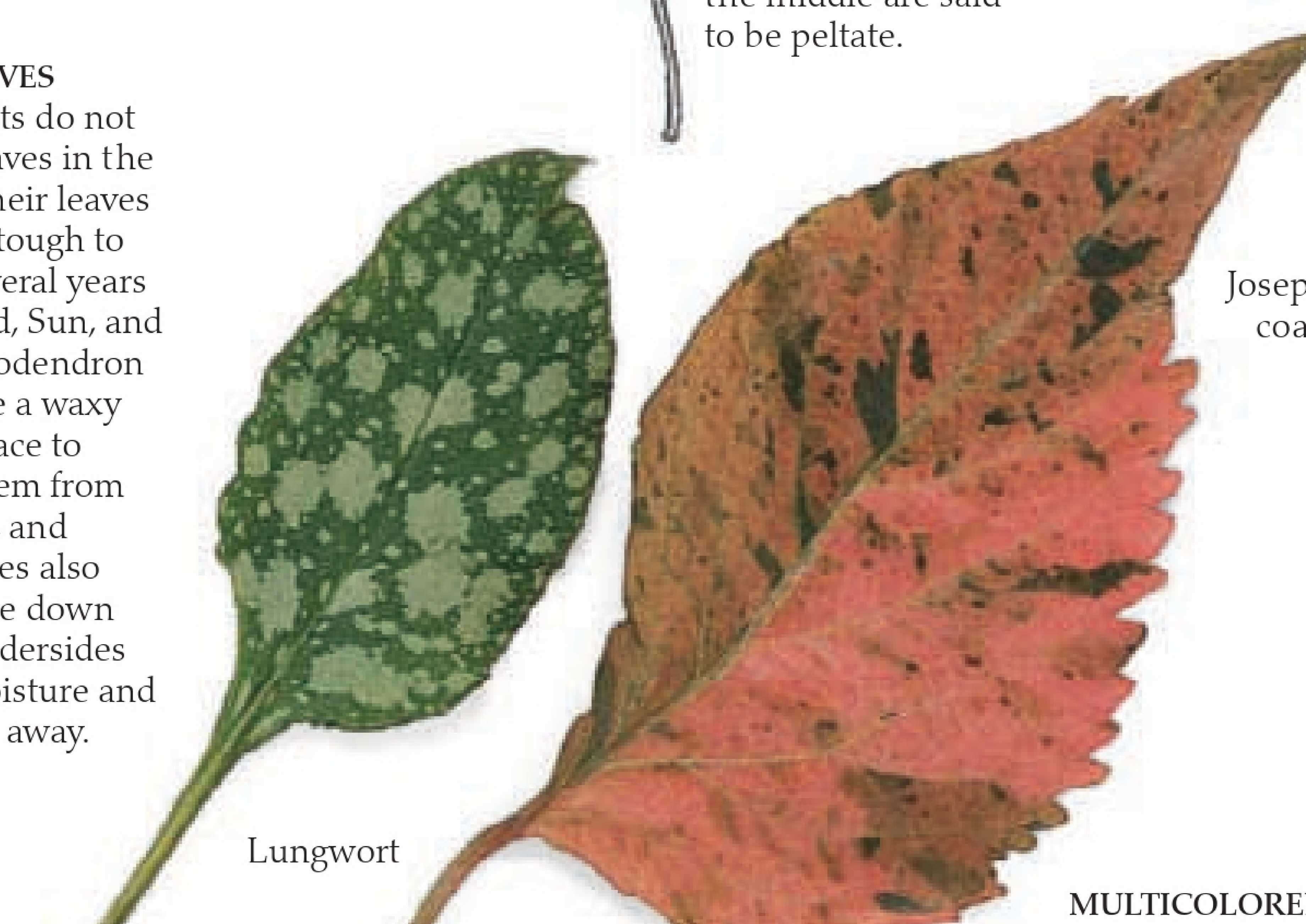
COMPOUND LEAF
Leaves made up of a number of individual leaflets are known as compound leaves.

SLASHED LEAVES
The Swiss cheese plant grows in tropical forests, clinging to trees for support. It probably gets its name from its unusual leaves. With all their slashes and perforations, they are reminiscent of some types of very holey Swiss cheese.

SIMPLE LEAF
Leaves without leaflets are known as simple leaves.

PELTATE LEAF
Circular leaves with the stalk inserted in the middle are said to be peltate.

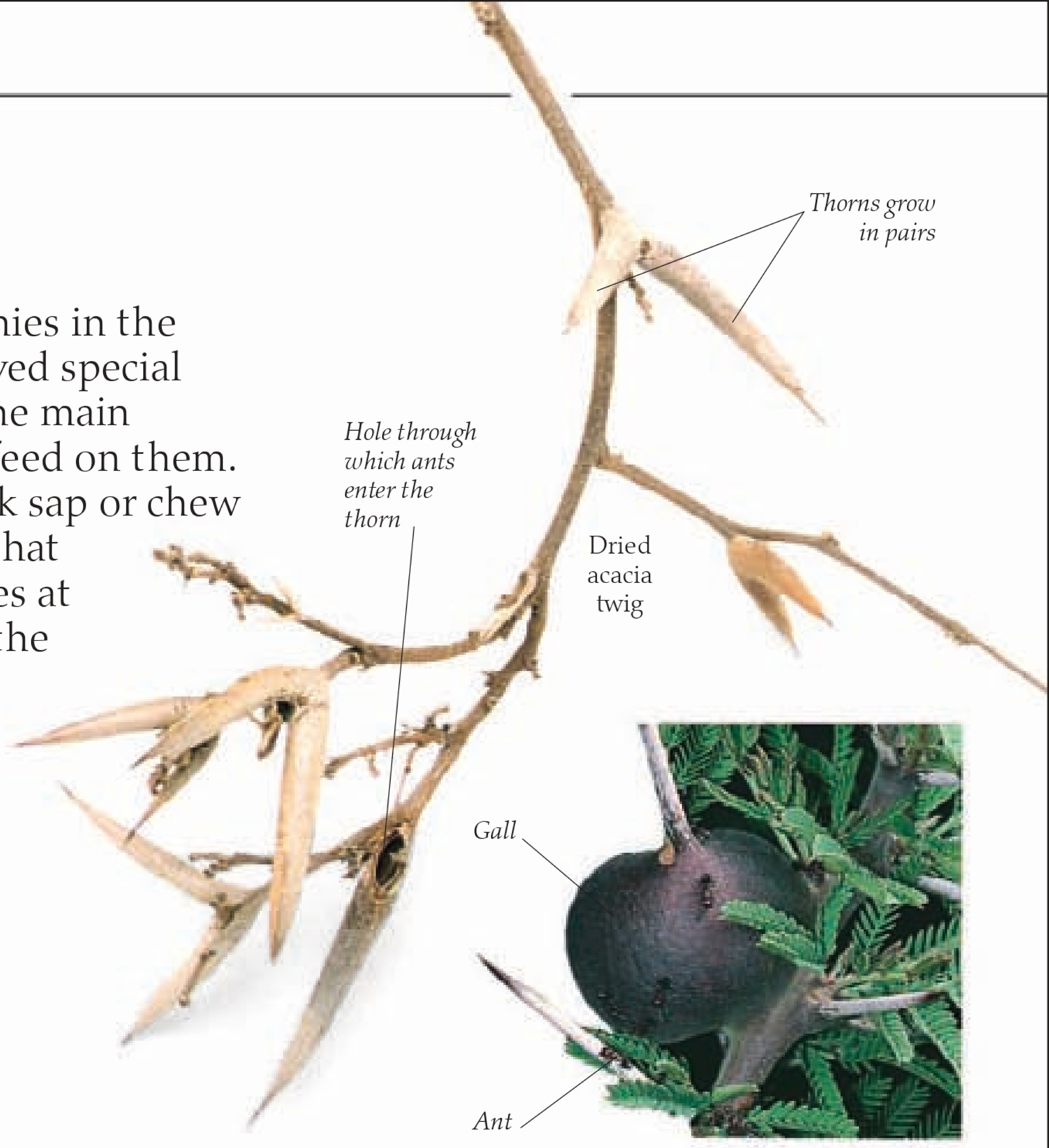
EVERGREEN LEAVES
Evergreen plants do not lose their leaves in the winter, so their leaves need to be tough to survive several years in the wind, Sun, and rain. Rhododendron leaves have a waxy upper surface to prevent them from drying out, and some species also have feltlike down on their undersides to retain moisture and keep insects away.



MULTICOLORED LEAVES
Variegated, or multicolored, leaves are often found in garden plants. The lungwort gets its name from its spotted leaves, which give it the appearance of a human lung. In the past, it was also used as a cure for lung diseases.

Self-defense

PLANTS CANNOT RUN AWAY from their enemies in the same way that animals do, so they have evolved special weapons and armor to protect themselves. The main enemies of most plants are the animals that feed on them. These range in size from tiny insects that suck sap or chew their way through leaves, to large mammals that eat entire plants. To keep the smallest enemies at bay, many plants have a mat of fine hairs on the surface of their leaves. Larger animals are deterred by means of special weaponry, including spines, thorns, and stings. As a final defense, many plants have chemicals in their cells that make them unpleasant to eat. Once an animal has tasted the plant, it is unlikely to want to repeat the experience.



Thorns grow in pairs

Hole through which ants enter the thorn

Dried acacia twig

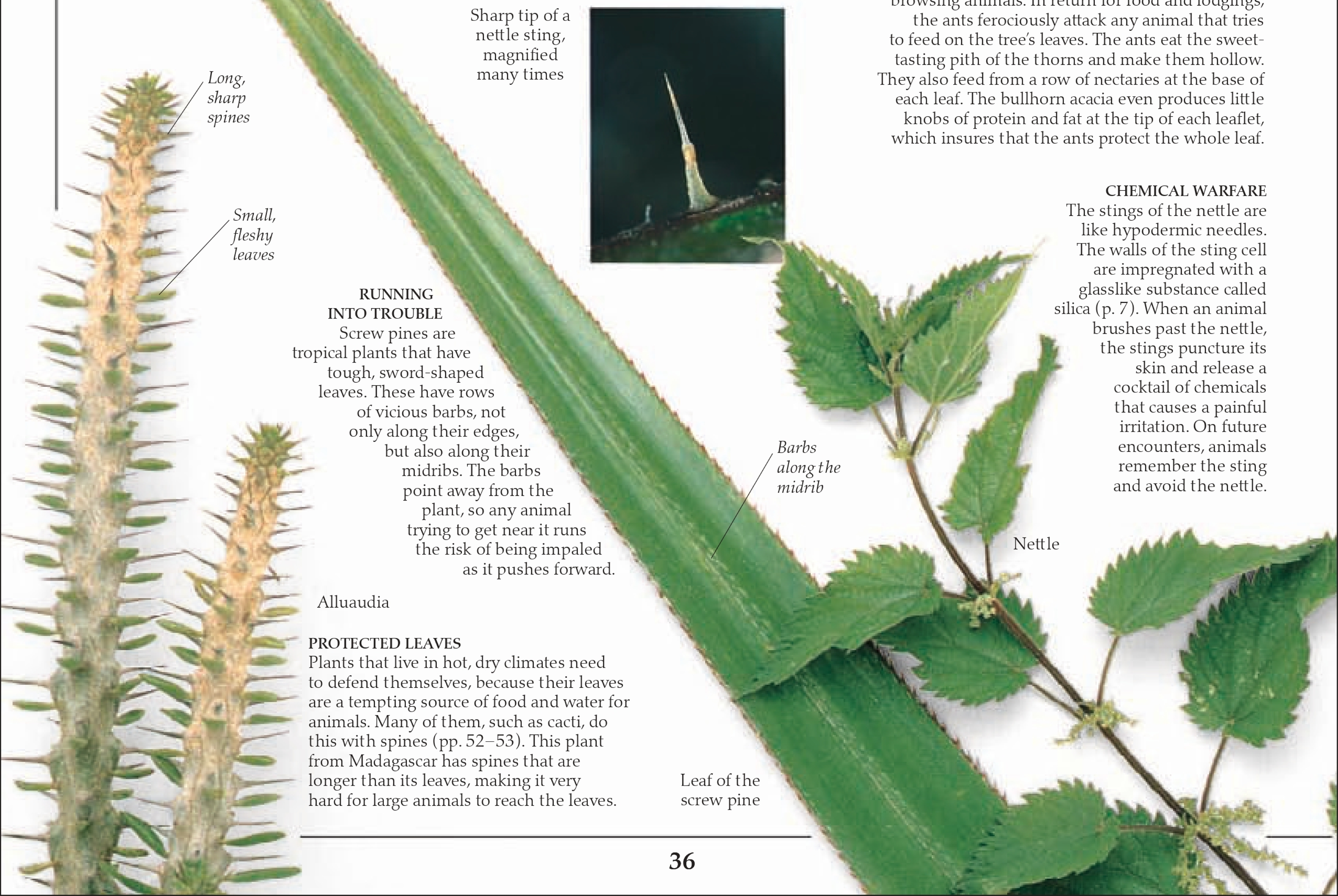
Gall

Ant

ANTS ON GUARD

Some acacia trees rely on ants to keep away browsing animals. In return for food and lodgings, the ants ferociously attack any animal that tries to feed on the tree's leaves. The ants eat the sweet-tasting pith of the thorns and make them hollow. They also feed from a row of nectaries at the base of each leaf. The bullhorn acacia even produces little knobs of protein and fat at the tip of each leaflet, which insures that the ants protect the whole leaf.

Sharp tip of a nettle sting, magnified many times



Barbs along the edge of the leaf

Barbs along the midrib

Leaf of the screw pine

RUNNING INTO TROUBLE

Screw pines are tropical plants that have tough, sword-shaped leaves. These have rows of vicious barbs, not only along their edges, but also along their midribs. The barbs point away from the plant, so any animal trying to get near it runs the risk of being impaled as it pushes forward.

Long, sharp spines

Small, fleshy leaves

Alluaudia

PROTECTED LEAVES

Plants that live in hot, dry climates need to defend themselves, because their leaves are a tempting source of food and water for animals. Many of them, such as cacti, do this with spines (pp. 52–53). This plant from Madagascar has spines that are longer than its leaves, making it very hard for large animals to reach the leaves.

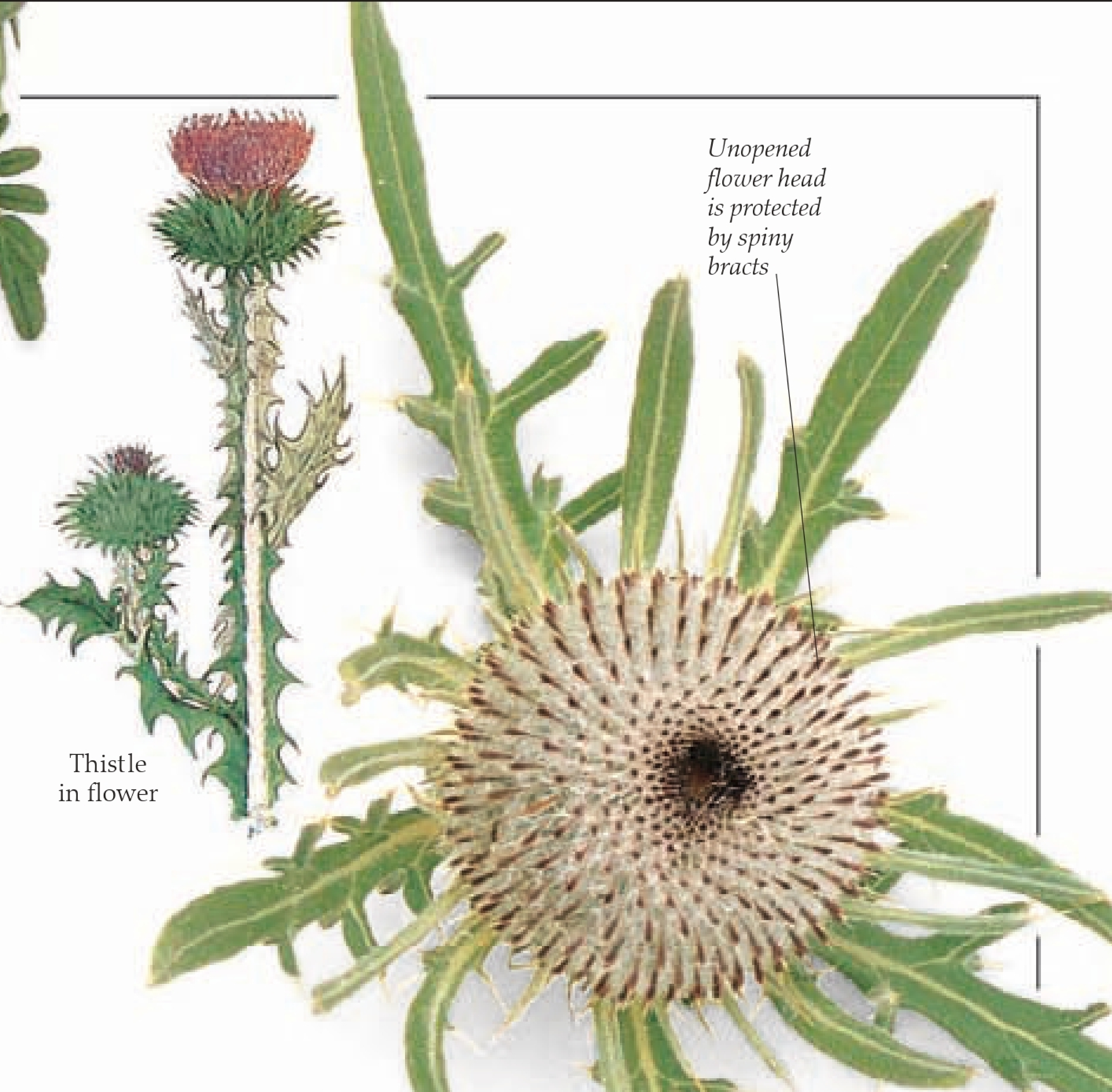
Nettle

CHEMICAL WARFARE

The stings of the nettle are like hypodermic needles. The walls of the sting cell are impregnated with a glasslike substance called silica (p. 7). When an animal brushes past the nettle, the stings puncture its skin and release a cocktail of chemicals that causes a painful irritation. On future encounters, animals remember the sting and avoid the nettle.

TANGLED IN A TRAP
Thorns on flexible stems snag passing animals and give them a painful lesson, teaching them not to get too close again. Thorns can be either straight, as on this rose, or they can be curved, which makes them dig in when they are pulled. Some plants have thorns pointing in both directions along their stems. If an animal gets tangled in the plant, the thorns catch no matter which way it pulls.

Thistle in flower

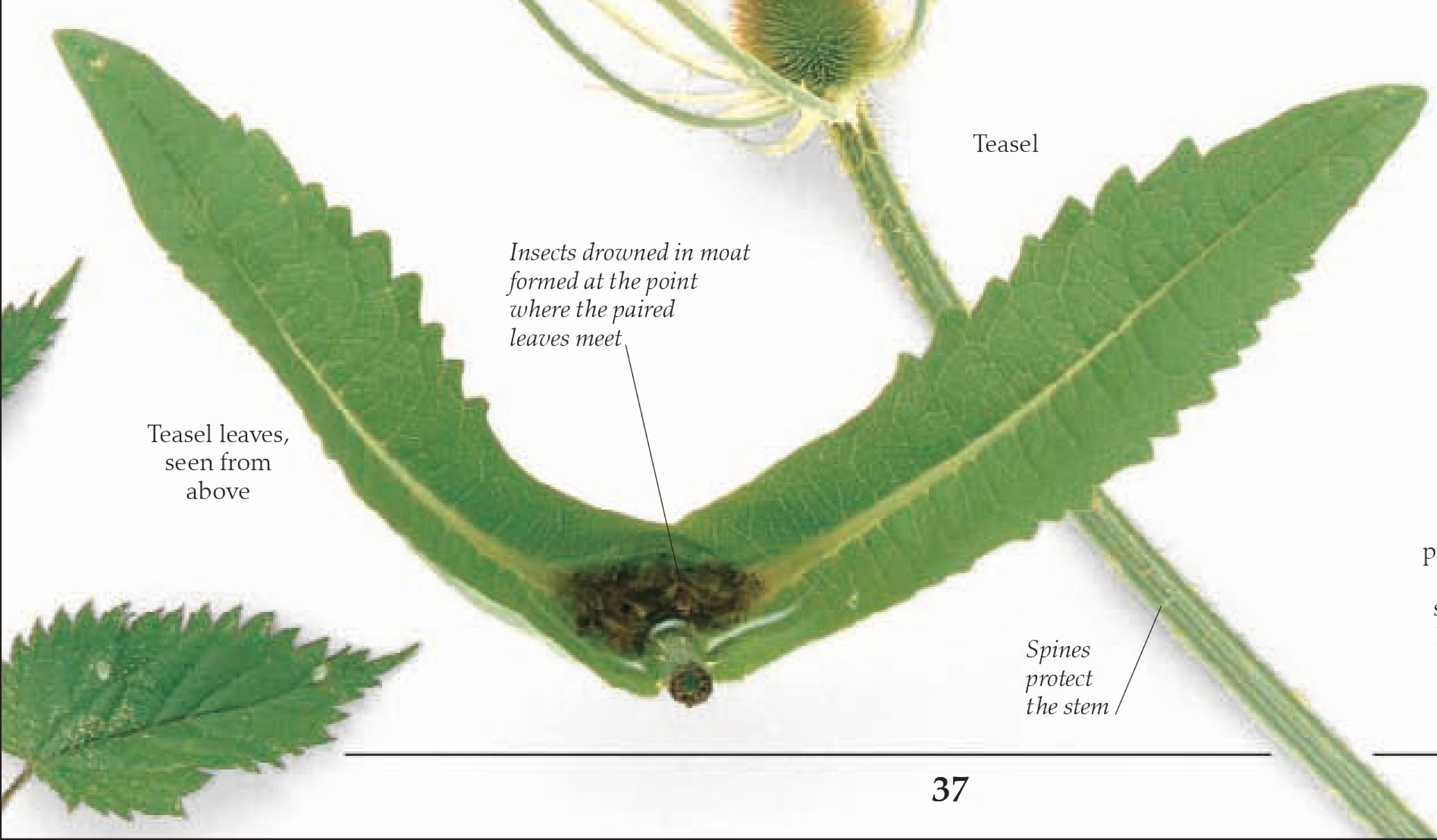


Woolly thistle

ARMORED FLOWERS
Thistles are extremely successful plants, partly because they have an effective seed dispersal system (p. 27), and partly because they are very well defended. Most thistles have spines on their stems as well as on their leaves. They also have spiny flaps, known as bracts, that protect their developing flower heads. The spines keep most animals away, although they do not deter sap-sucking insects such as aphids, which often feed in large numbers on thistles.

DEATH BY DROWNING
Pairs of leaves on the stem of the teasel meet to form little cups that fill with water after rain. Each cup acts like a moat to protect the plant. Snails and insects try to climb the plant to feed on its young leaves but, faced with the water, they either turn back or fall into the moat and drown.

Teasel



Teasel leaves, seen from above

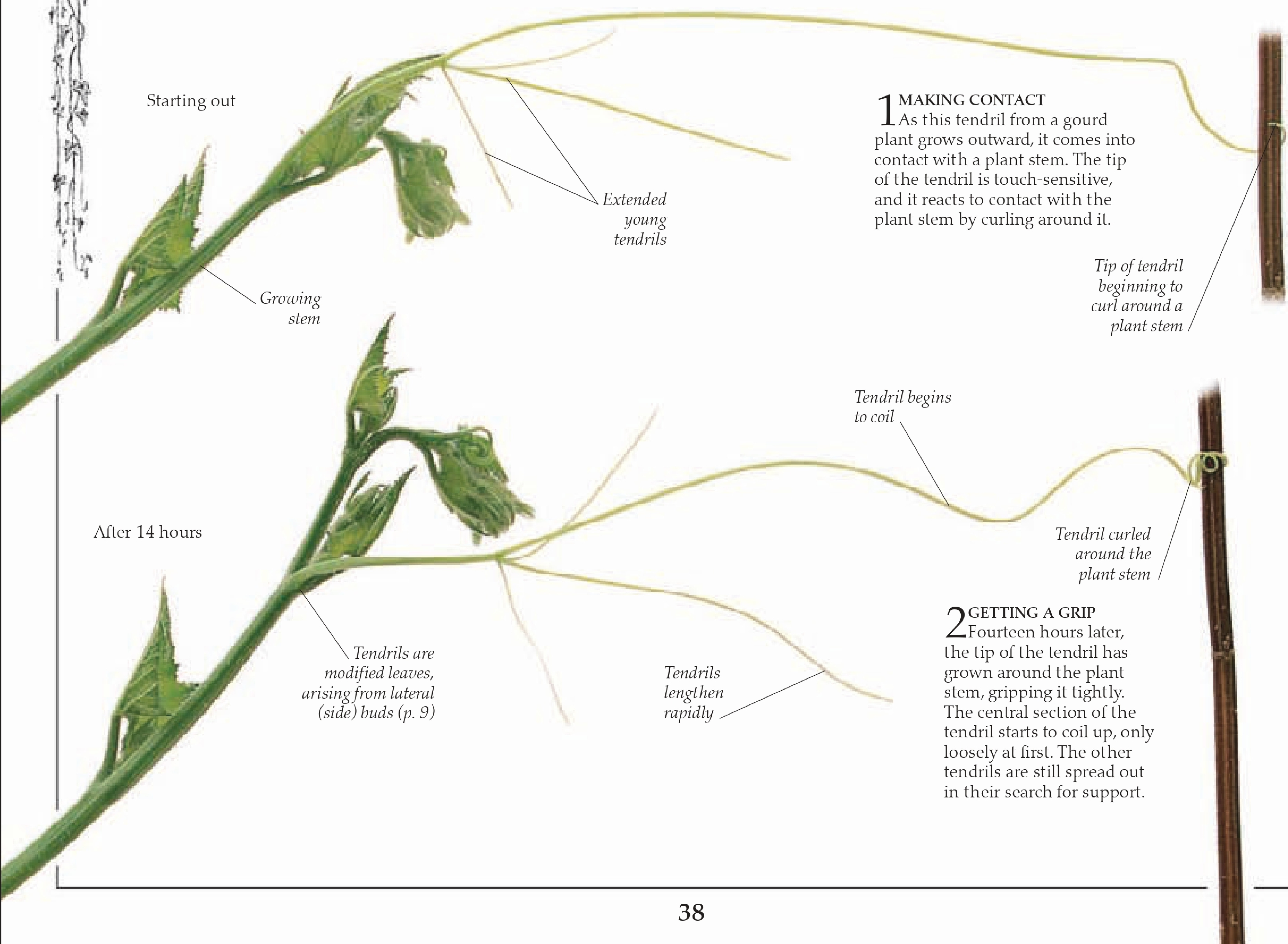
Holly leaves

EXTRA WEAPONRY
Holly leaves are not only very leathery, but they also have tough spines all around their edges. Compared to the leaves of deciduous trees, which lose their leaves every fall, they suffer very little from animal attack. These leaves are from a variety of holly that has been cultivated to produce extra spines. On holly trees, the lowest leaves are usually the spiniest. Those nearest the top may have no spines at all, since they are in less danger of being eaten.

Creepers and climbers

Wherever there is moisture and warmth, plants struggle against each other for light. The tallest plant usually gets the greatest share, but it also has to spend the most energy in growing a strong stem, or a tree trunk, to hold up its leaves. But there are some plants—epiphytes (pp. 46–47) and climbers—that take a shortcut to the top. They take advantage of other plants and even buildings to get a place in the light with much less effort. Epiphytes may grow on the trunks or upper branches of trees and are lifted up with them as they grow. These plants do not have roots on the ground and are able to absorb all the water they need from the air and rainwater. Climbers need supports. Some twine themselves around a plant, while others put out touch-sensitive feelers, or tendrils, that curl around the support when they come into contact with it. A third group of climbers raise themselves by means of stiff side branches, prickles, roots, or hairs.

GROWING IN A SPIRAL
Plants that grow in a spiral will twist in a set direction. Scarlett runner plants always twist in a clockwise direction, a detail noticed by the artist who made this 16th-century woodcut of a bean plant climbing up a stick.



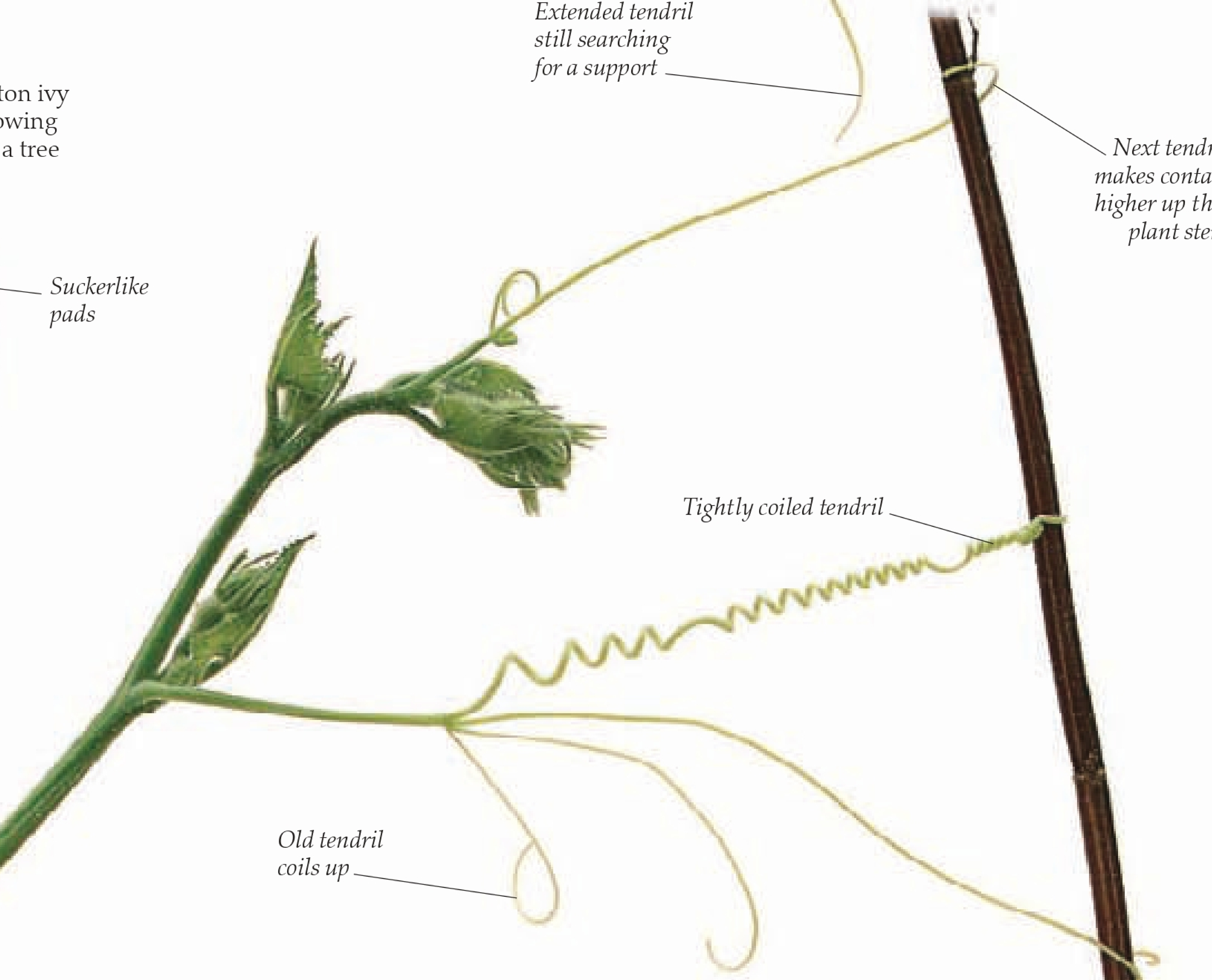
1 MAKING CONTACT
As this tendril from a gourd plant grows outward, it comes into contact with a plant stem. The tip of the tendril is touch-sensitive, and it reacts to contact with the plant stem by curling around it.

2 GETTING A GRIP
Fourteen hours later, the tip of the tendril has grown around the plant stem, gripping it tightly. The central section of the tendril starts to coil up, only loosely at first. The other tendrils are still spread out in their search for support.

3 COILING UP
Twenty-four hours after making contact, the tendril has now formed a double coil. This makes it shorten, so the plant is pulled toward the support. Another bunch of tendrils is now starting to appear farther along the growing stem.

Boston ivy growing on a tree

STICKING TO A SURFACE
Many plants related to the grape vine have tendrils with small, suckerlike pads at the tip. These stick to other plants or walls. The tendrils then coil up to hold the plant to the surface.



CLIMBING WITH ROOTS
Ivy holds on to trees and vertical surfaces by means of short adventitious roots (roots that grow from the stems). These anchor themselves in crevices, supporting the plant as it climbs upward. Although ivy may look like a parasite (pp. 44–45), it is not. It uses other plants only for support, but unfortunately sometimes kills them in the process by smothering them with its leaves.

Ivy

Ivy climbing over a statue

4 MAKING FAST
Forty-eight hours after making contact, the tendril has coiled up tightly like a spring, and the plant is securely supported. The coils allow the tendril to stretch, so that it does not break when the plant is blown by the wind.

Meat-eaters

Although man-eating plants belong to the world of fiction, there are many plants that eat insects and other small animals. These carnivorous, or meat-eating, plants fall into two groups. Some species, such as the Venus flytrap (pp. 42–43), have active traps, with moving parts that catch their prey. Other species have inactive traps with no moving parts. They simply attract their victims with a scent reminiscent of food, and then catch them on a sticky surface or drown them in a pool of fluid. The victims of carnivorous plants are mostly insects. Once an insect has been caught, it is slowly dissolved by digestive fluids produced by the plant. After many days, all that is left is the insect's exoskeleton—the hard outer casing of the body. The rest of the insect has been absorbed by the plant. Carnivorous plants can make food from sunlight like ordinary plants. The insects they catch are simply used as an extra source of food because they grow in waterlogged ground, where the soil is deficient in nitrates and other essential nutrients.

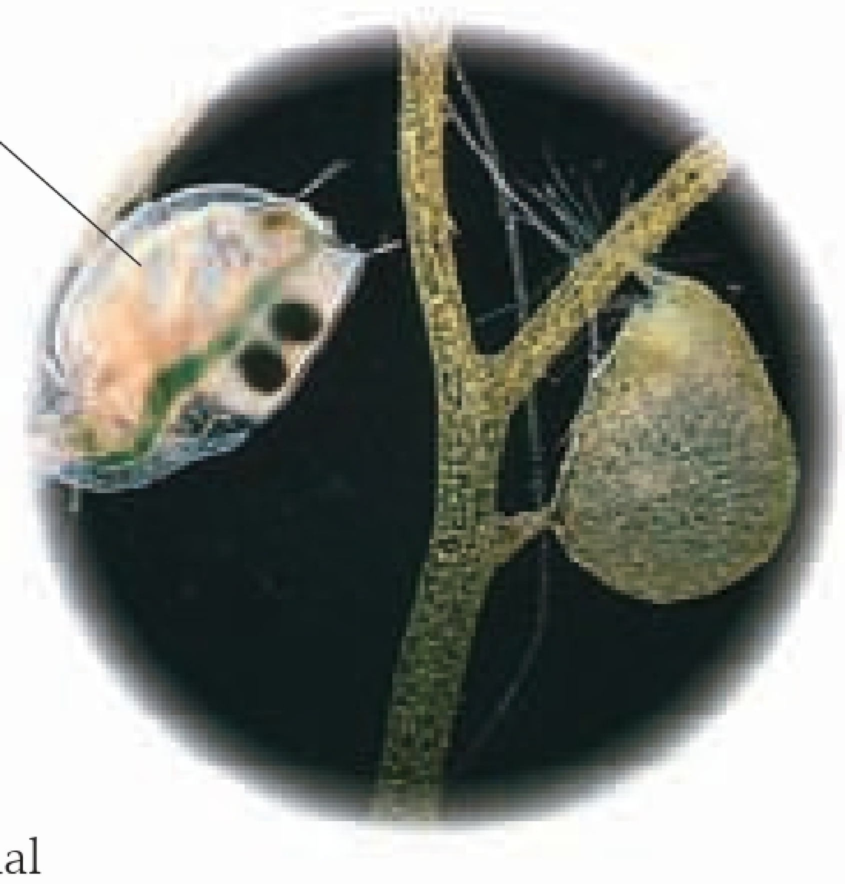
SPECIALIZED LEAVES
All the animal traps shown on these two pages are modified leaves. The leaves of the Portuguese sundew are so sticky that people used to hang them up indoors to catch flies.

FATAL ATTRACTION
This colorful nepenthes pitcher lures passing insects.

THE STICKY SUNDEWS
The leaves of sundews are covered in hairs that produce droplets of sticky glue. When an insect lands on one of the leaves, it sticks to the hairs, which then fold over, trapping it.

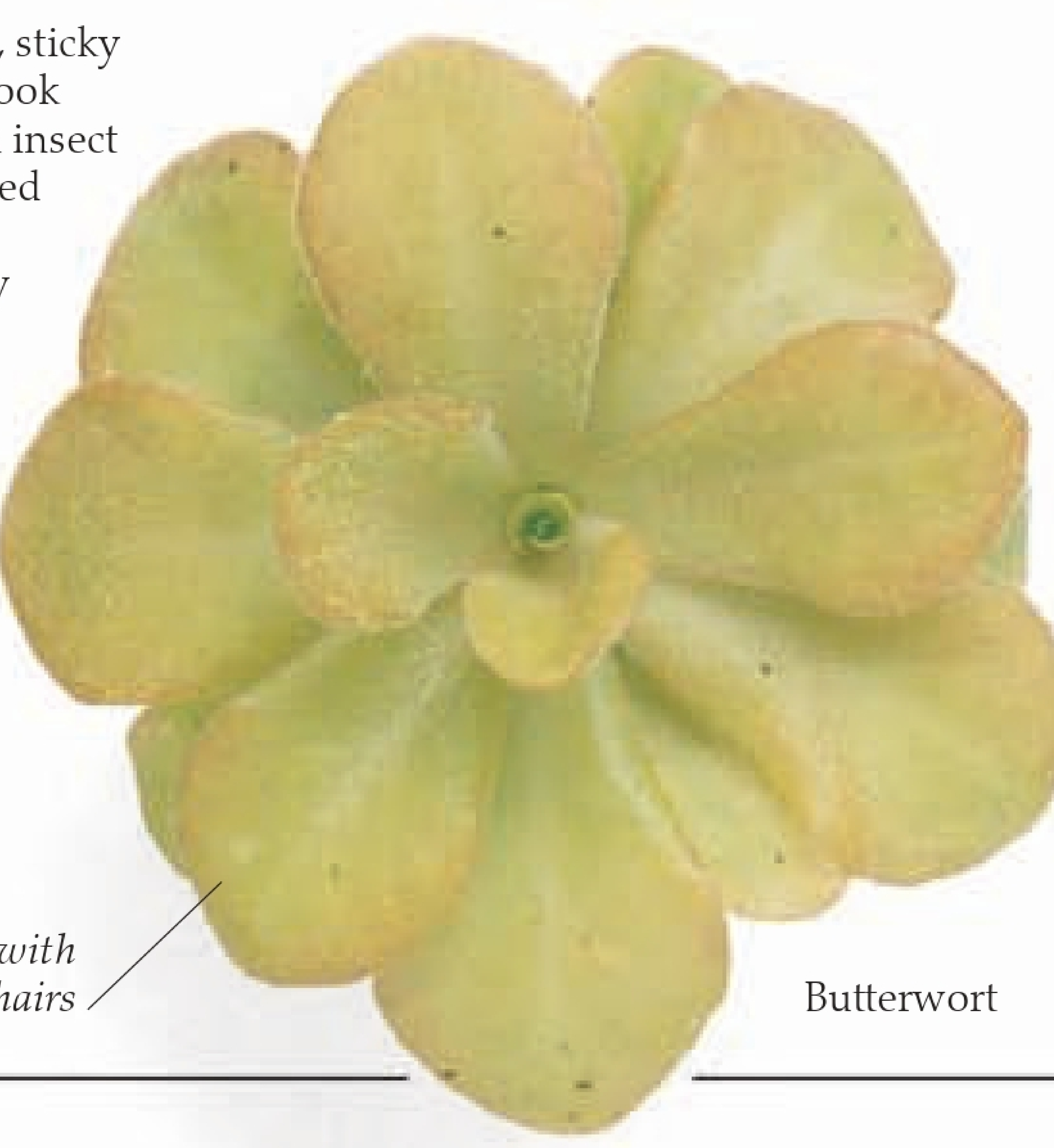
Magnified view of a fly trapped by hairs on a sundew leaf

Cape sundew



UNDERWATER TRAPS
Bladderworts are water plants that develop traps, in the form of tiny bladders, on their feathery leaves. If a small water animal swims past, the bubblelike bladder snaps open and the animal is sucked inside.

LYING IN WAIT
Butterworts have circles of flat, sticky leaves. These plants may not look very threatening, but when an insect lands on a leaf, it becomes glued to the surface and eventually dies. The edges of the leaf very gradually curl inward, and the insect is digested. There are about 50 species of butterwort, most of which grow in marshy places.



Butterwort

Hanging nepenthes pitcher

An 18th-century engraving of hanging nepenthes pitcher plants

Leaf of a hanging pitcher plant

American pitcher plant has a frilly rim

American pitcher plant, also called a parrot pitcher plant

DEATH IN THE SWAMPS
American pitcher plants catch their food in the same way as the hanging pitcher plants, but instead of hanging from leaves, their pitchers grow up from the ground. The inside of each pitcher is lined with scales of wax, so the insects are unable to hang on to the sides as they tumble toward the liquid below. Once in the liquid, the scales prevent the insects from climbing back up the sides of the pitcher.

COBRA LILY
The California pitcher plant, or cobra lily, looks similar to a snake rearing up and flicking out its tongue. Insects, lured by nectar, enter the plant through the mouthlike opening. Once inside the pitcher, they are confused by light shining down through small translucent areas at the top. In the attempt to escape, the insects fly continually toward the light, but eventually become exhausted, dropping into the liquid and drowning.

Patches of translucent cells

Entrance to the pitcher

Cobra lily

HANGING PITCHER PLANT
The traps of hanging pitcher plants grow at the ends of their leaves. Each one is like a pitcher and has a lid to keep out the rain. Insects are lured to the pitcher by its bright color, and by sweet nectar produced around its rim. The surface of the rim is slippery, so when insects try to settle on it, they lose their footing, fall inside, and drown in the fluid at the bottom. Hanging pitcher plants grow in southeast Asia. The largest pitchers are 14 in (35 cm) deep and hold a cup of fluid.

Rim where nectar is produced

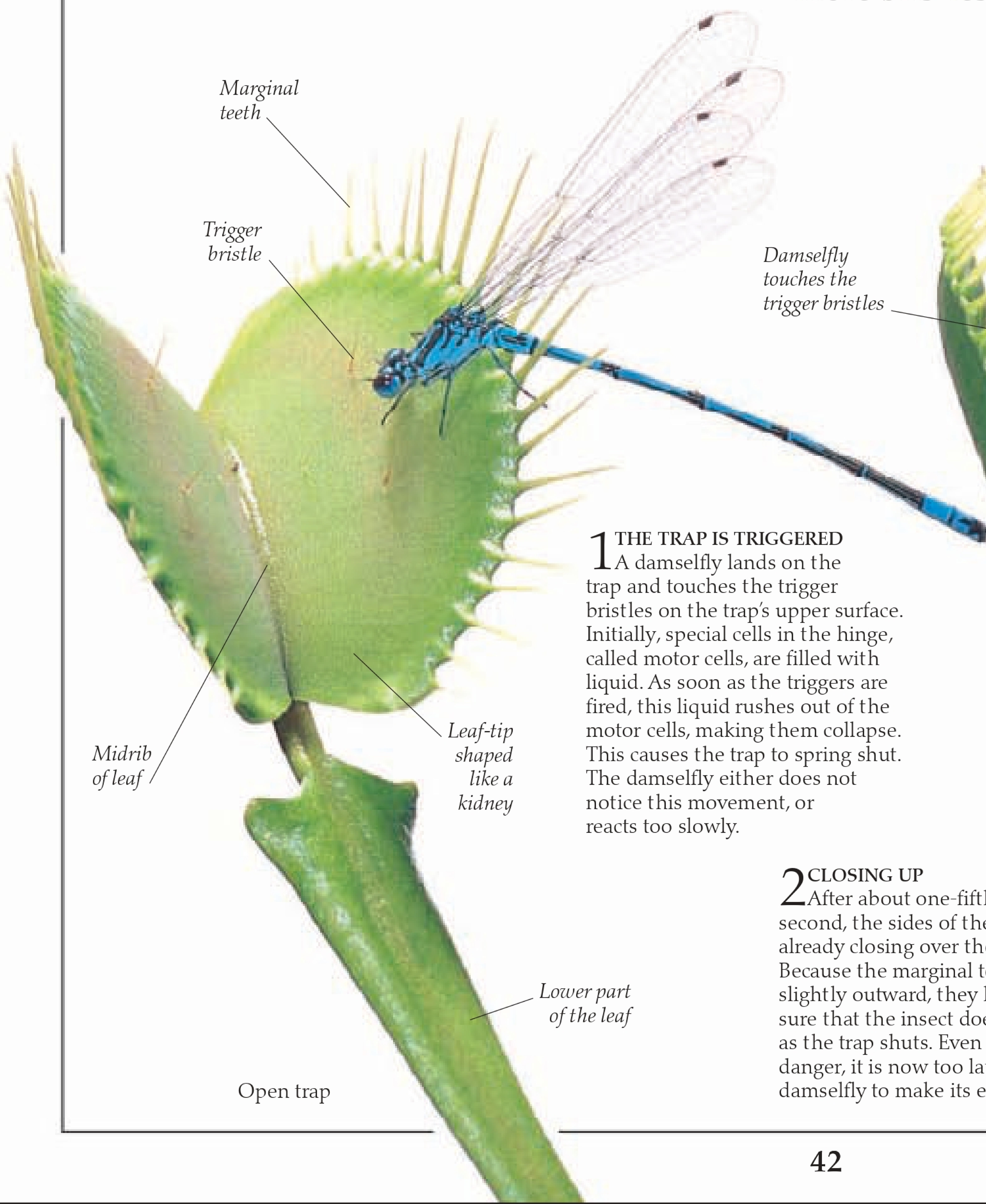
These insects are being digested slowly in the fluid that collects at the bottom of the pitcher

Vertical cross-section of a hanging pitcher

Caught in a trap

A MOST HORRIBLE TORTURE
Like the Venus flytrap, humans have also been known to inflict a frightful and lingering death on their victims, as this rather gruesome engraving shows.

To AN UNWARY INSECT, the unusually shaped tip of a Venus flytrap leaf appears most inviting. Not only is the insect attracted by what looks like a safe landing place, but it is also tempted by the promise of food in the form of nectar. But it is all a trick. As soon as the insect settles, the leaf-tip springs to life with lightning speed. Within a second, the hapless insect finds itself trapped, as the two halves of the leaf-tip snap shut. There is a second, slower phase of closure after the plant has tested what it has caught using sensory glands on the upper surface of the leaf-tip. If the prey contains protein, the trap closes fully, and digestion begins. The traps of the Venus flytrap are formed by two kidney-shaped lobes at the tip of the leaf, with a hinge formed by the midrib. The whole of the leaf is green and therefore able to photosynthesize (pp. 14–15). Large bristles on the upper surface of the trap work like triggers with a clever device. If just one bristle is touched, by a raindrop for example, the trap stays open. But if two or more bristles are touched in quick succession, it quickly shuts to catch its victim.



Open trap

1 THE TRAP IS TRIGGERED
A damselfly lands on the trap and touches the trigger bristles on the trap's upper surface. Initially, special cells in the hinge, called motor cells, are filled with liquid. As soon as the triggers are fired, this liquid rushes out of the motor cells, making them collapse. This causes the trap to spring shut. The damselfly either does not notice this movement, or reacts too slowly.

After one-fifth of a second

2 CLOSING UP
After about one-fifth of a second, the sides of the trap are already closing over their victim. Because the marginal teeth point slightly outward, they help to make sure that the insect does not fall out as the trap shuts. Even if it has sensed danger, it is now too late for the damselfly to make its escape.

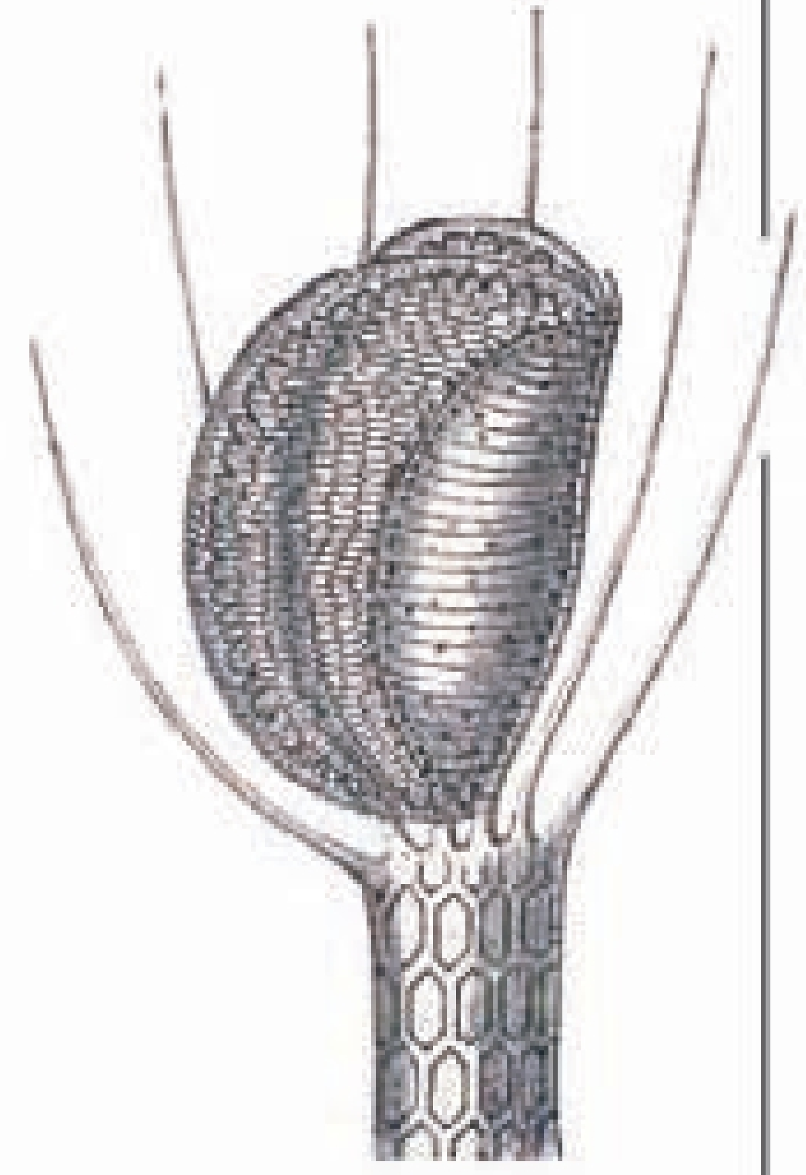
An early 19th-century painting of the Venus flytrap by Redoute, who painted the plants kept by the French Empress Josephine at Malmaison (p. 61)

GROWING A FLYTRAP

The first living specimen of the Venus flytrap arrived in England from North America in the mid-18th century. Never before had such an unusual and spectacular plant been seen live in Europe, and it aroused great curiosity among botanists. Today, Venus flytraps can be grown as pot plants. Because they come from waterlogged bogs with slightly acid soil, they must never be allowed to dry out and are best planted in peat. It is important to water them with distilled water, because tap water often contains dissolved minerals that will reduce the plant's chances of survival. Venus flytraps do produce clusters of white flowers, but this does not often happen with indoor specimens, especially if they are fed frequently with insects.

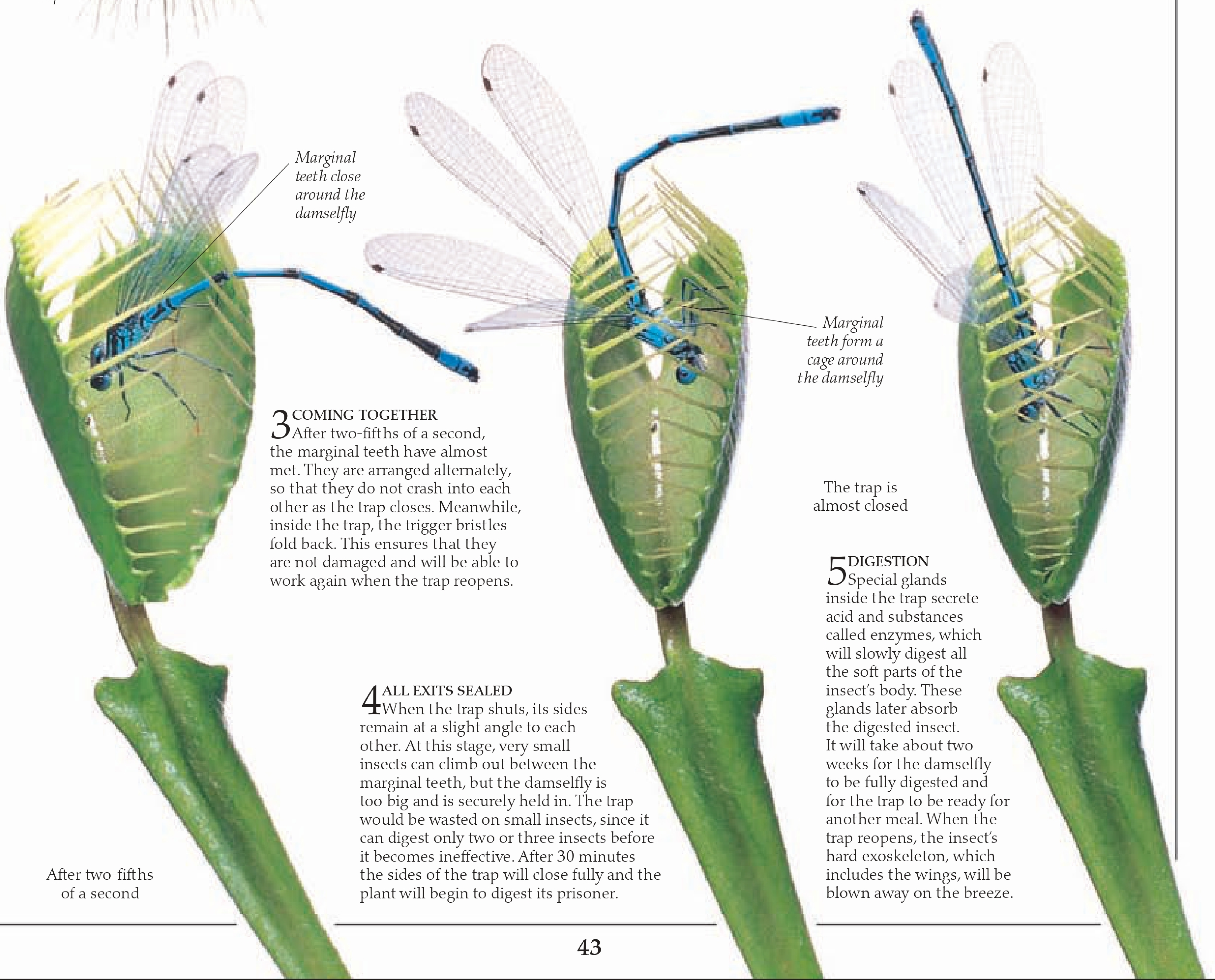
A WATERY HABITAT

Venus flytraps come from the bogs of North Carolina. Each plant grows from a small rhizome and produces several traps. Each trap can catch about three insects before it withers.



FLOATING TRAPS

This waterwheel plant is a small water plant that belongs to the same family of plant as the Venus flytrap and the sundews. Its leaves end in small traps that catch tiny water animals. They can close in one-fiftieth of a second.



3 COMING TOGETHER

After two-fifths of a second, the marginal teeth have almost met. They are arranged alternately, so that they do not crash into each other as the trap closes. Meanwhile, inside the trap, the trigger bristles fold back. This ensures that they are not damaged and will be able to work again when the trap reopens.

4 ALL EXITS SEALED

When the trap shuts, its sides remain at a slight angle to each other. At this stage, very small insects can climb out between the marginal teeth, but the damselfly is too big and is securely held in. The trap would be wasted on small insects, since it can digest only two or three insects before it becomes ineffective. After 30 minutes the sides of the trap will close fully and the plant will begin to digest its prisoner.

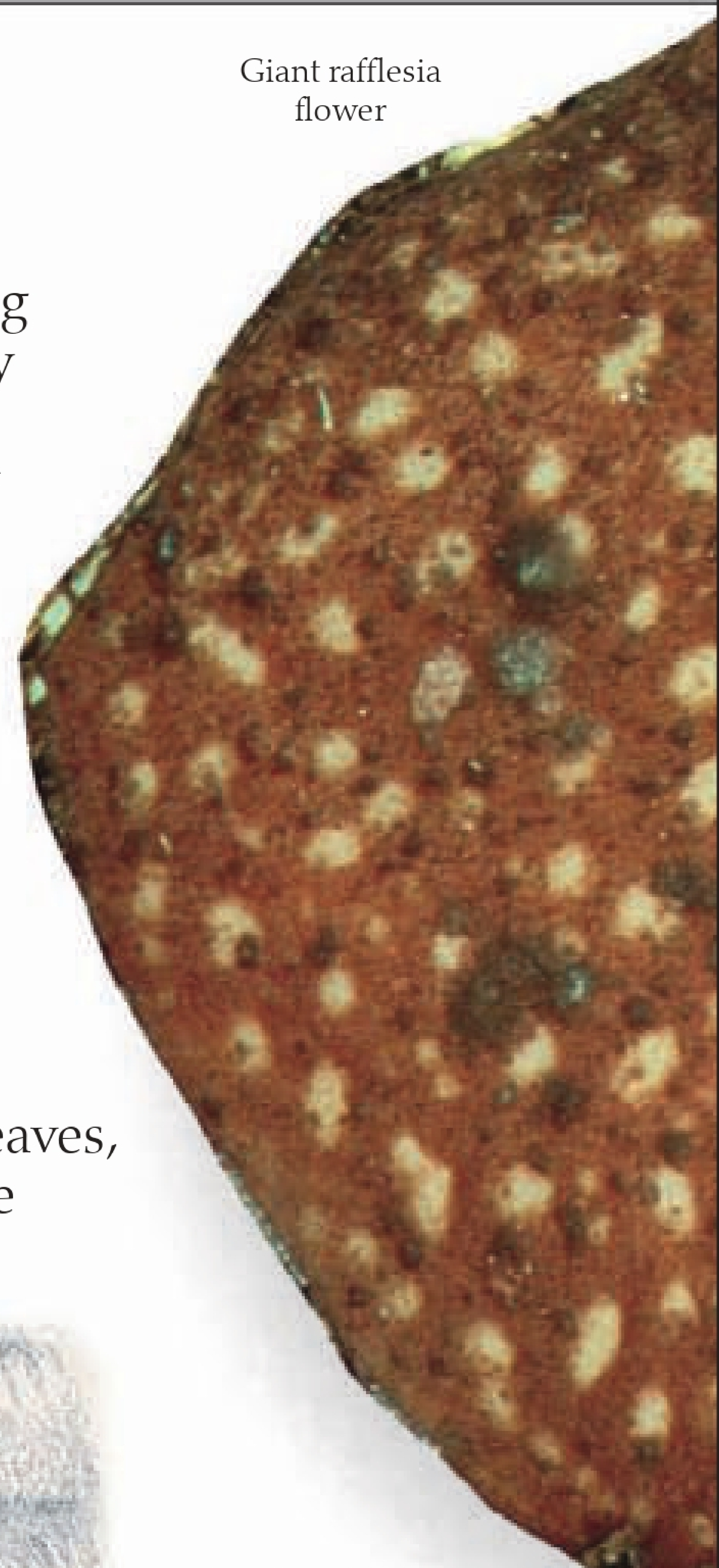
5 DIGESTION

Special glands inside the trap secrete acid and substances called enzymes, which will slowly digest all the soft parts of the insect's body. These glands later absorb the digested insect. It will take about two weeks for the damselfly to be fully digested and for the trap to be ready for another meal. When the trap reopens, the insect's hard exoskeleton, which includes the wings, will be blown away on the breeze.

Parasitic plants

OLD TRADITION
The custom of kissing under mistletoe may be older than you think, for this plant was sacred to the ancient British priests known as the Druids some 2,000 years ago.

PARASITIC PLANTS ARE CHEATS. Rather than making their own food using the energy from sunlight, they have developed a means of stealing the food made by other plants, known as host plants. Because they do not need sunlight, many parasitic plants spend most of their lives hidden from sight. They attach themselves to the stems or roots of their host plants by means of suckers, known as haustoria. The haustoria penetrate the host's food channels and absorb the sugars and minerals that the parasitic plant needs to live. The world of parasitic plants is a complicated one. Some plants, such as mistletoe and the eyebrights, are only partly parasitic and are known as hemiparasites. These plants have green leaves, so they can use the Sun's energy to make some food for themselves.

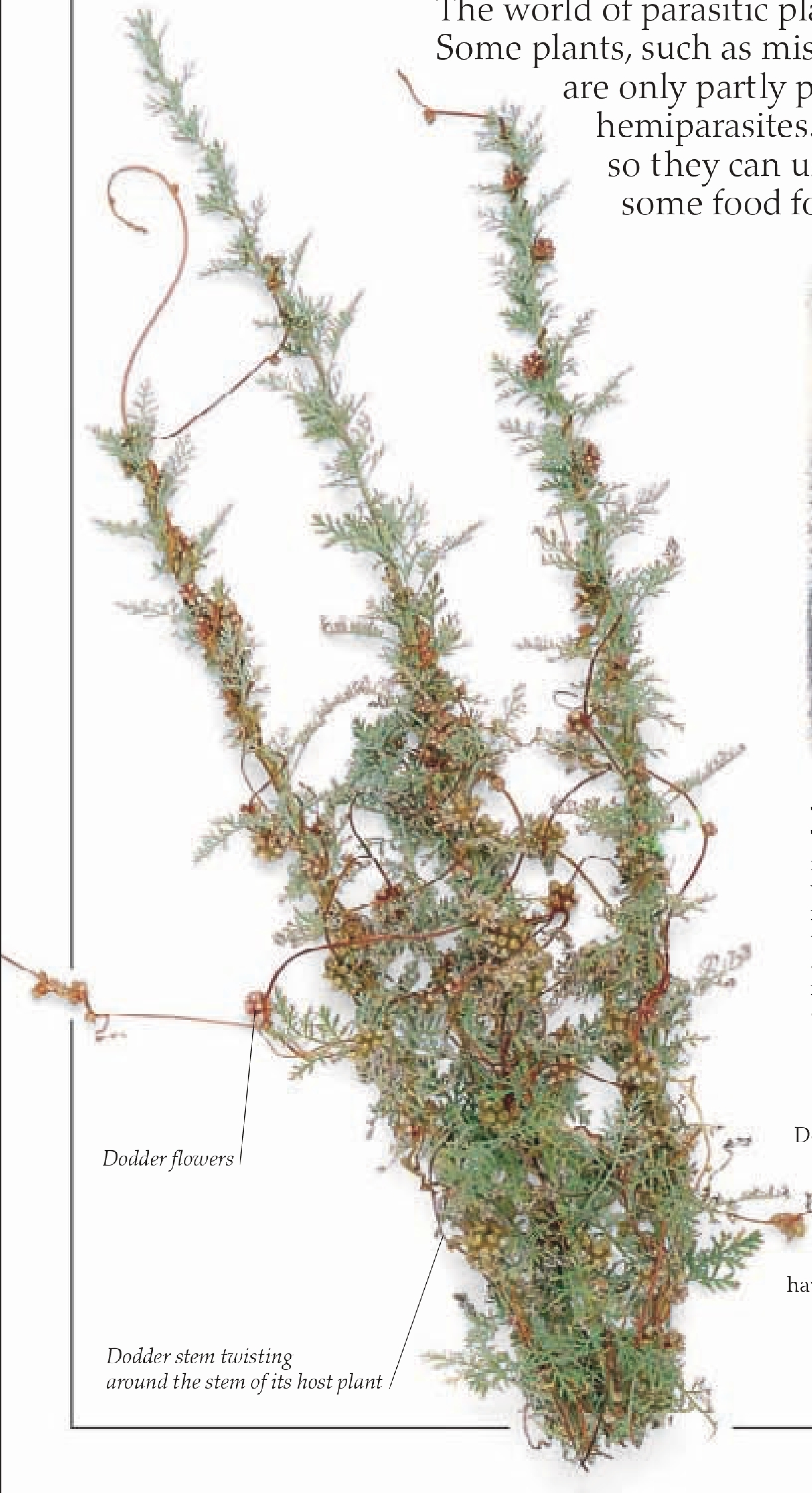


Giant rafflesia flower

Giant sepals unfold as the flower opens

Sepals are thick and fleshy

THE STINKING GIANT
The world's heaviest flower is a species of rafflesia, a parasite that lives on the roots of vines in the jungles of southeast Asia. Each flower weighs nearly 15 lb (7 kg), and reaches up to 3 ft (1 m) in diameter. The flower fills the air with a putrid smell that attracts pollinating flies. This plant is the largest of 50 species, all of them completely parasitic.



Dodder flowers

Dodder stem twisting around the stem of its host plant

MAKING A BREAK-IN
Dodder stems spread over their hosts looking like lengths of tangled string. These stems develop haustoria that penetrate their host's food channels. Young dodders have roots to help them become established, but as they grow the roots wither away.

Dodder flowers

Haustoria penetrating the stem of its host

Plant passengers

NOT ALL PLANTS that live on others are parasites (pp. 44–45). In fact, many more of them are simply passengers that grow on larger plants, such as trees, without causing them any harm. Such plants are described as epiphytic, and many of them can get all the water they need simply by absorbing it from the air, or by collecting it in structures formed for the purpose. They collect minerals by extracting them from trickling rainwater and plant debris. Being an epiphyte gives a small plant a chance to collect a lot of light without the need for tall stems. So successful is this way of life that few trees are without their passengers. In cool parts of the world, epiphytes are usually small, simple plants such as algae, lichens, and mosses. But in moist regions close to the equator, they are much larger. In addition to the plants that spend their entire lives up in the trees, there are others that start or end their lives in this way. Some creeping plants, known as stranglers, germinate on trees and then become rooted in the soil. Others climb up on to plants but then their roots wither away, leaving them perched high up near the light.

FOREST CLIMBERS
These large, woody climbers, known as lianas, grow in the forests of Central America.

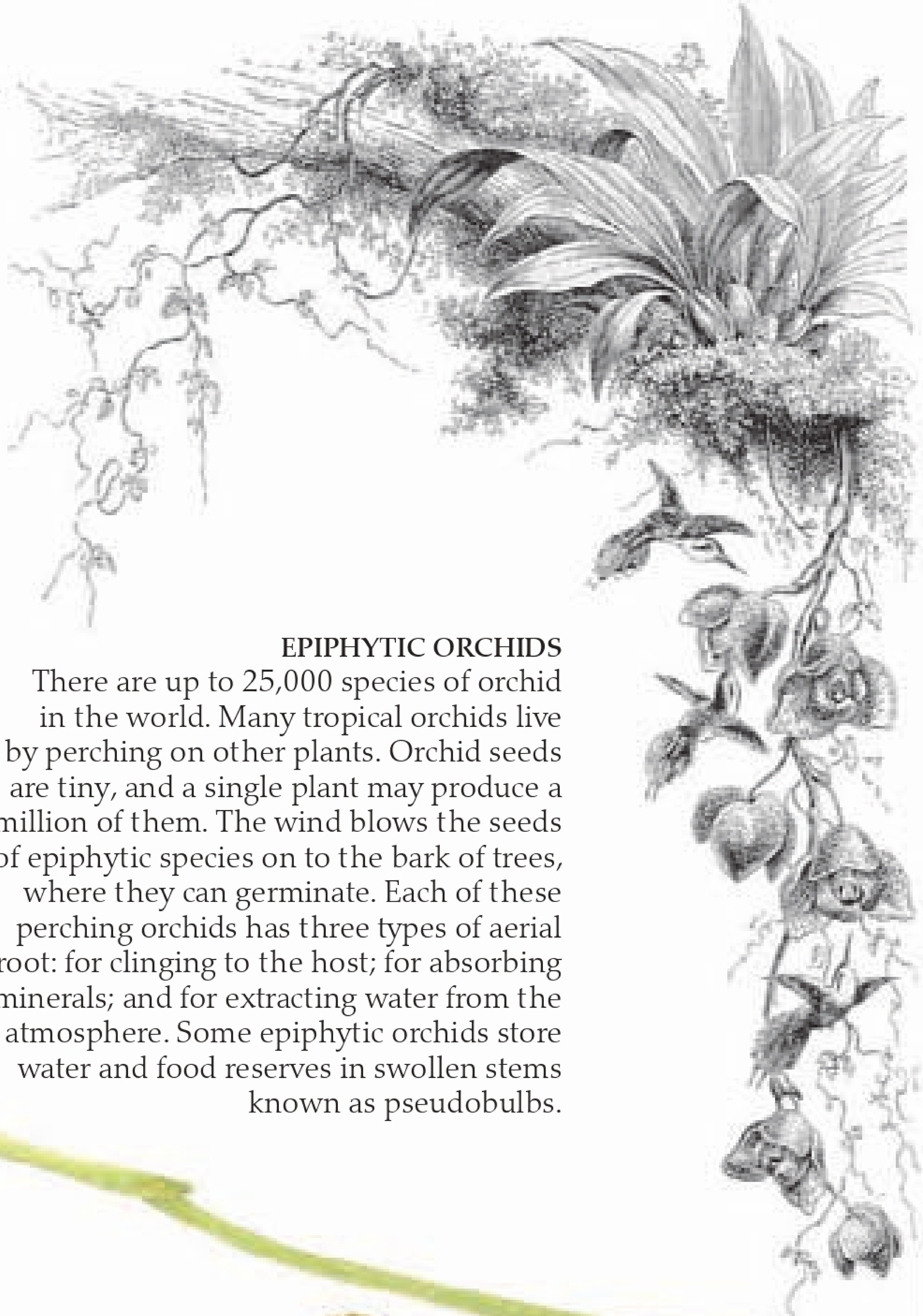
Leaves have a special coating to reduce water loss

High up in the trees it is easier for plants to collect enough light

HIGH-RISE FLOWERS
In the forests of Sri Lanka, epiphytic orchids can be found growing on the trees. Most epiphytic plants live in tropical and subtropical forests, because they require humid conditions.

THE BROMELIAD'S PRIVATE POND
Bromeliads are a family of plant that includes the pineapple. Many bromeliads grow on other plants. Instead of collecting water with long, aerial roots like orchids, they channel rainwater into a central reservoir (right) with their stiff, spiky leaves. Hairs on the leaves then absorb the water so the plant can use it. A big bromeliad holds well over 1 gallon (5 liters) of water and provides a home for water animals such as tree-frog tadpoles.

A species of moth orchid



EPIPHYTIC ORCHIDS

There are up to 25,000 species of orchid in the world. Many tropical orchids live by perching on other plants. Orchid seeds are tiny, and a single plant may produce a million of them. The wind blows the seeds of epiphytic species on to the bark of trees, where they can germinate. Each of these perching orchids has three types of aerial root: for clinging to the host; for absorbing minerals; and for extracting water from the atmosphere. Some epiphytic orchids store water and food reserves in swollen stems known as pseudobulbs.

Flowers produce minutes seeds to be dispersed by wind

Thick, trailing aerial roots collect moisture as well as minerals from trickling rainwater

Tarzan used lianas to swing from tree to tree across the jungle

Tarzan, a fictional hero of books, movies, and comics

Entwined liana stems

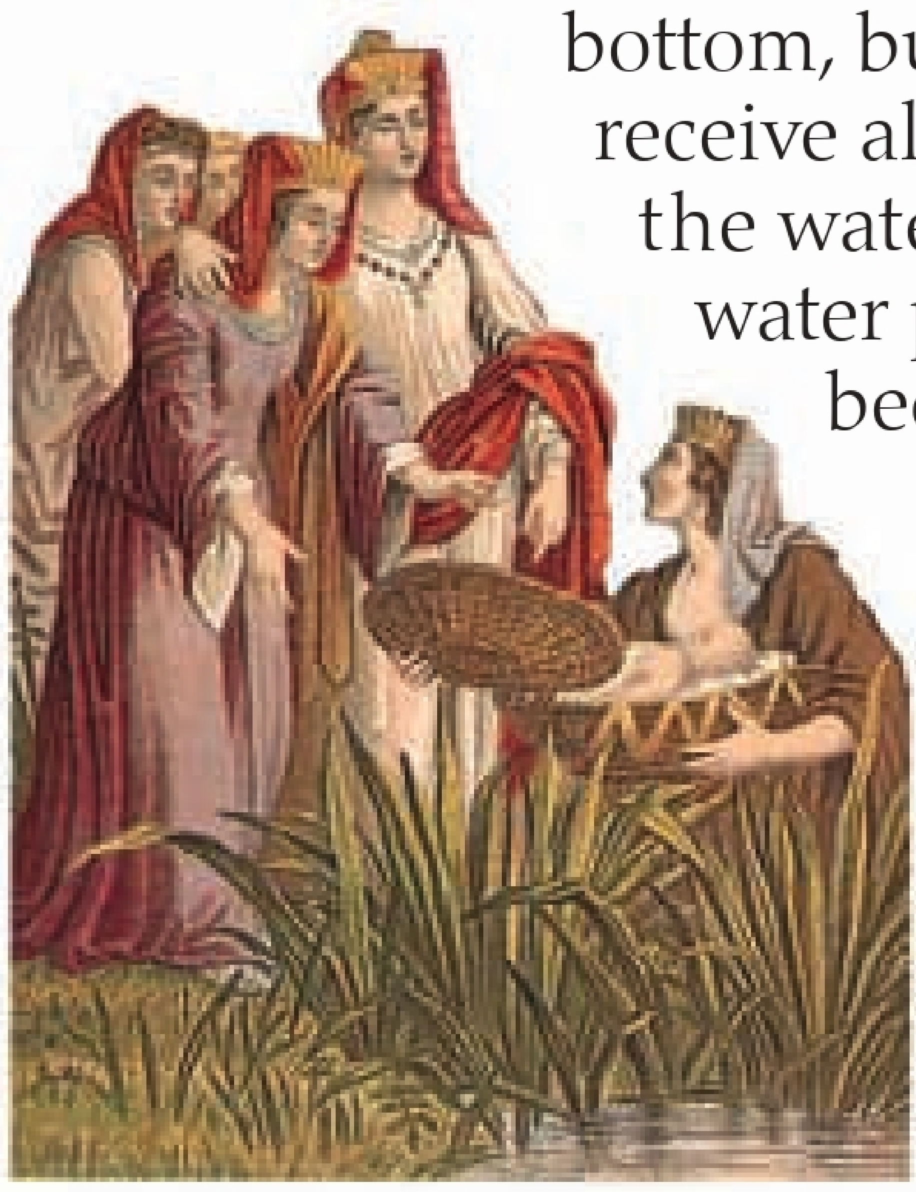
Liana stems make a natural rope

NATURAL ROPES

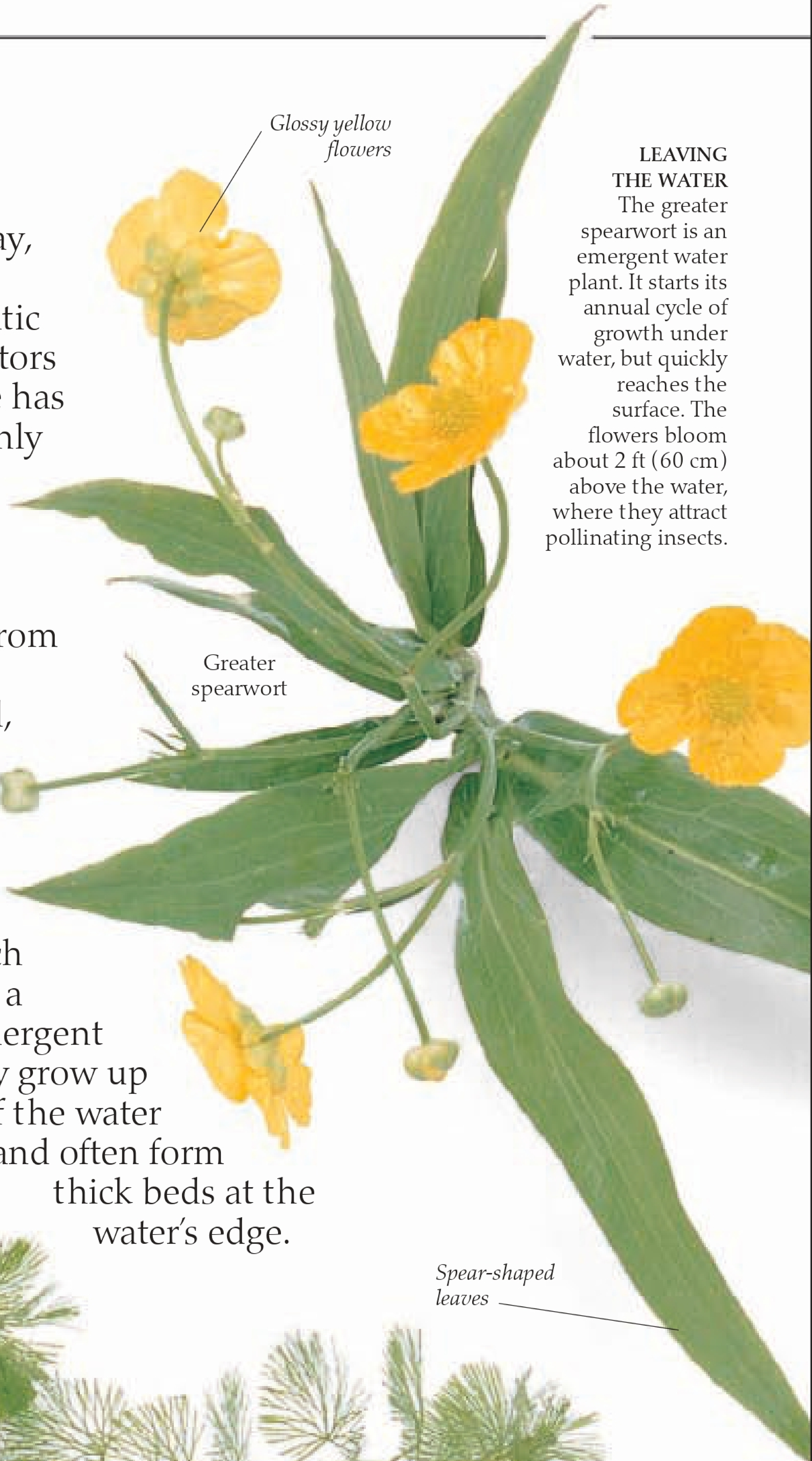
Lianas are climbing plants with flexible woody stems. Sometimes they twine around each other for mutual support. If the original support dies and decays, the lianas are left suspended from the forest canopy. Other plants, called stranglers, start life above ground and then grow roots downward. Their roots form a mesh around the trunks of trees and eventually kill the support.

Adapting to water

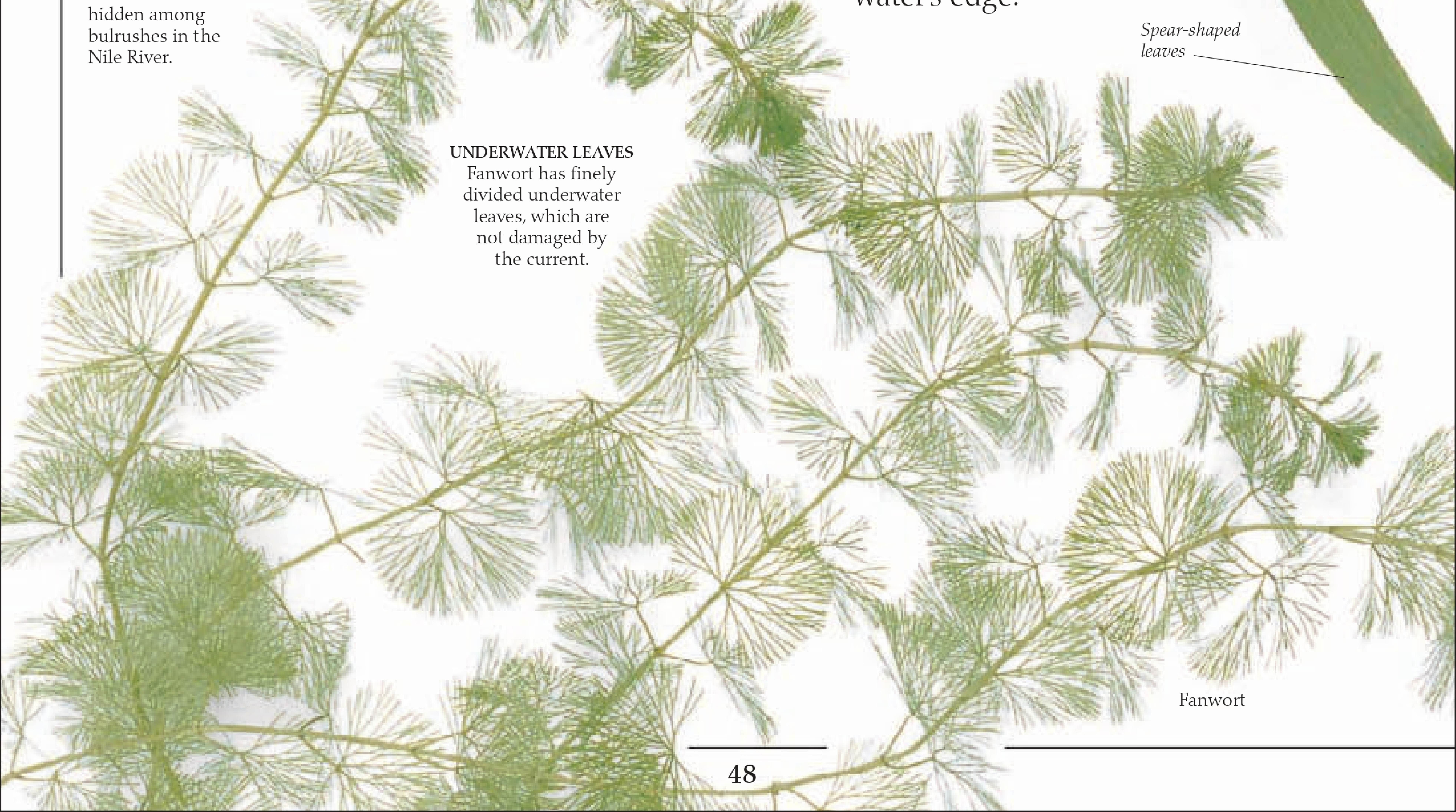
THE FIRST PLANTS ON EARTH evolved in water. Today, water still teems with microscopic plants that have changed little from those distant ancestors. But aquatic flowering plants have a different history. Their ancestors originally left water and evolved on land, but as time has gone by they have returned to the watery habitat. Only a few flowering plants, such as the eel-grasses, live in the sea. Far more plant species live in ponds, lakes, and rivers. Most of them are rooted to the bottom, but some have no roots and receive all the nutrients they need from the water instead of the soil. Some water plants are not often noticed, because they spend all their lives under water. Species like the water lilies are more obvious, because their leaves float on the surface. Plants such as reeds and rushes form a group known as emergent plants. They grow up out of the water and often form thick beds at the water's edge.



HISTORIC HIDEOUT
The Bible tells how the Pharaoh's daughter discovered the infant Moses hidden among bulrushes in the Nile River.



LEAVING THE WATER
The greater spearwort is an emergent water plant. It starts its annual cycle of growth under water, but quickly reaches the surface. The flowers bloom about 2 ft (60 cm) above the water, where they attract pollinating insects.



UNDERWATER LEAVES
Fanwort has finely divided underwater leaves, which are not damaged by the current.

Victorian engraving of papyrus growing by the Nile River in Egypt

FLOATING ON THE SURFACE
When young, the leaves of water lilies are rolled up under water like short tubes. In the spring, the leaves reach the surface, where they open out and lie flat to form pads. In some ponds and lakes, water lilies and other plants with floating leaves can completely cover the water's surface, robbing submerged plants of the light they need to survive. The leaves are tough and leathery, so water easily runs off their surface.

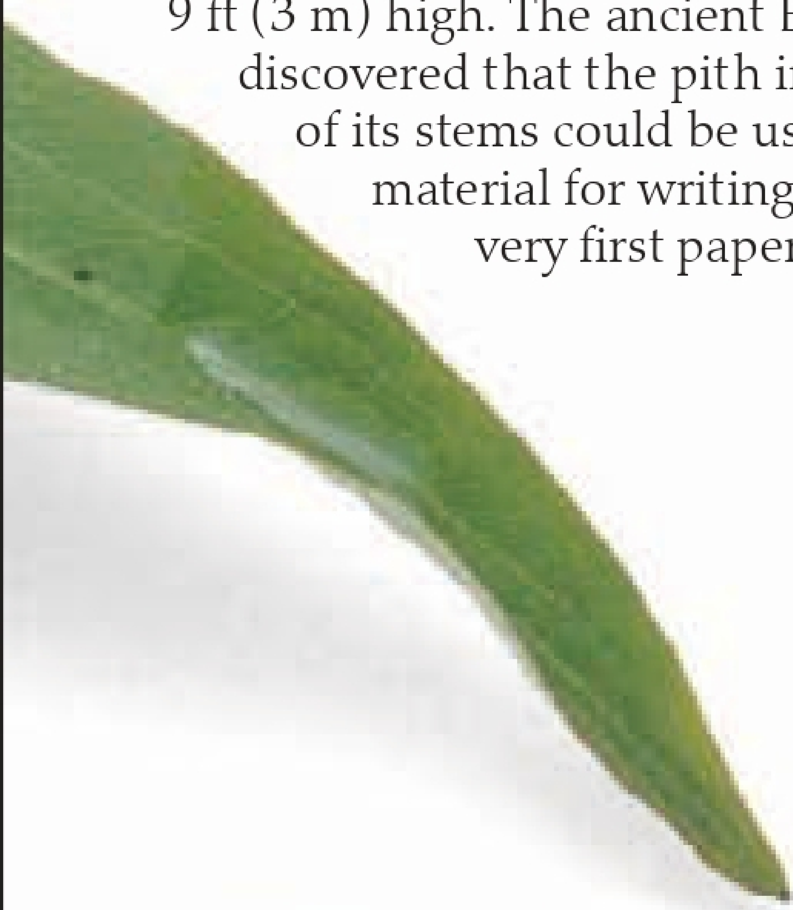
A PLANT FOR PAPER
Papyrus is a giant reed that grows up to 9 ft (3 m) high. The ancient Egyptians discovered that the pith in the middle of its stems could be used to make a material for writing on—the very first paper.

Tough, waxy surface repels water

Flowers bloom above the water

Flexible stalks attach the leaves to the roots, which are anchored in the muddy bottom

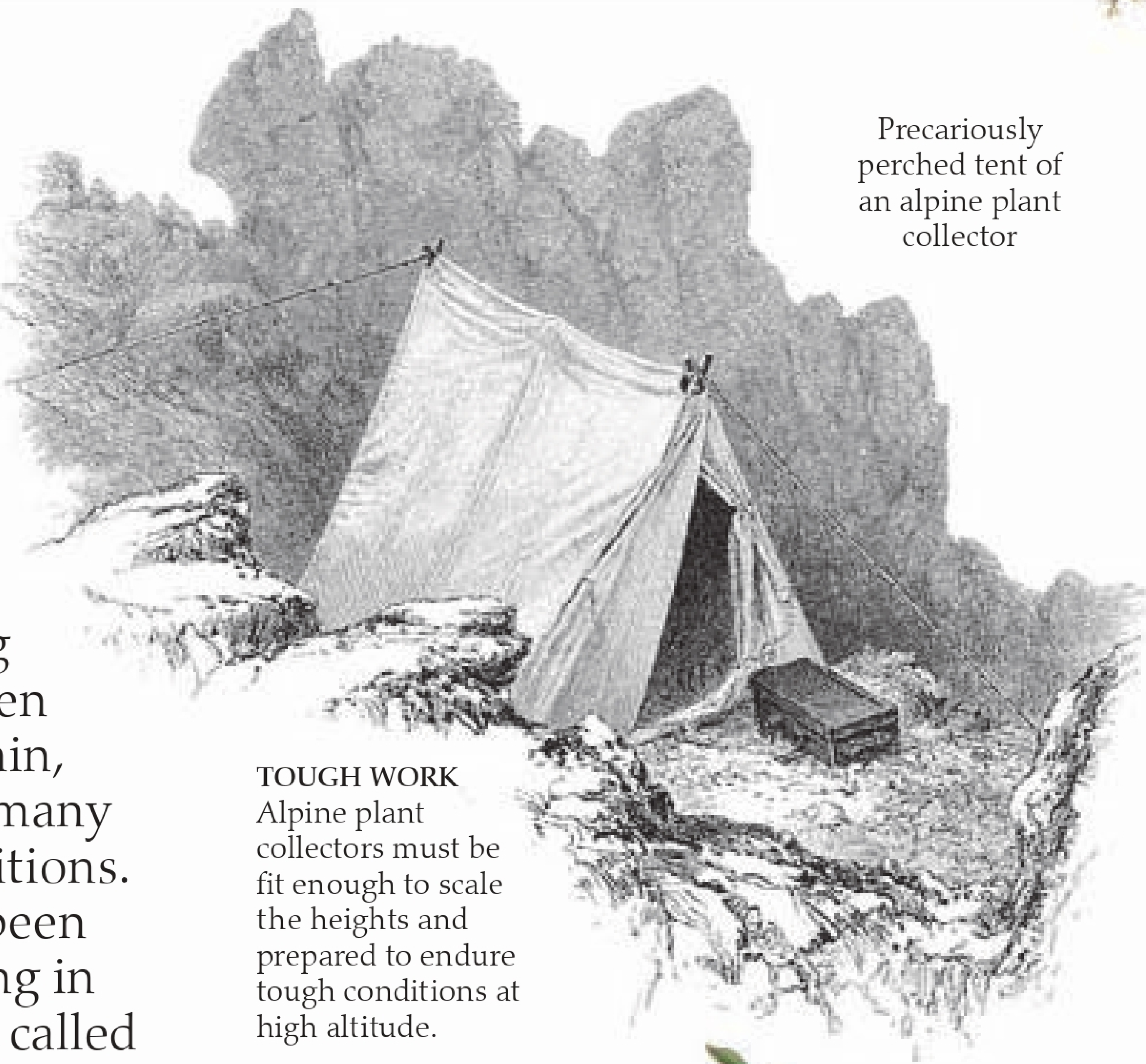
Water lily



AMAZONIAN GIANT
The floating leaves of the Amazonian water lily can reach a diameter of more than 6 ft (2 m).

Surviving above the snowline

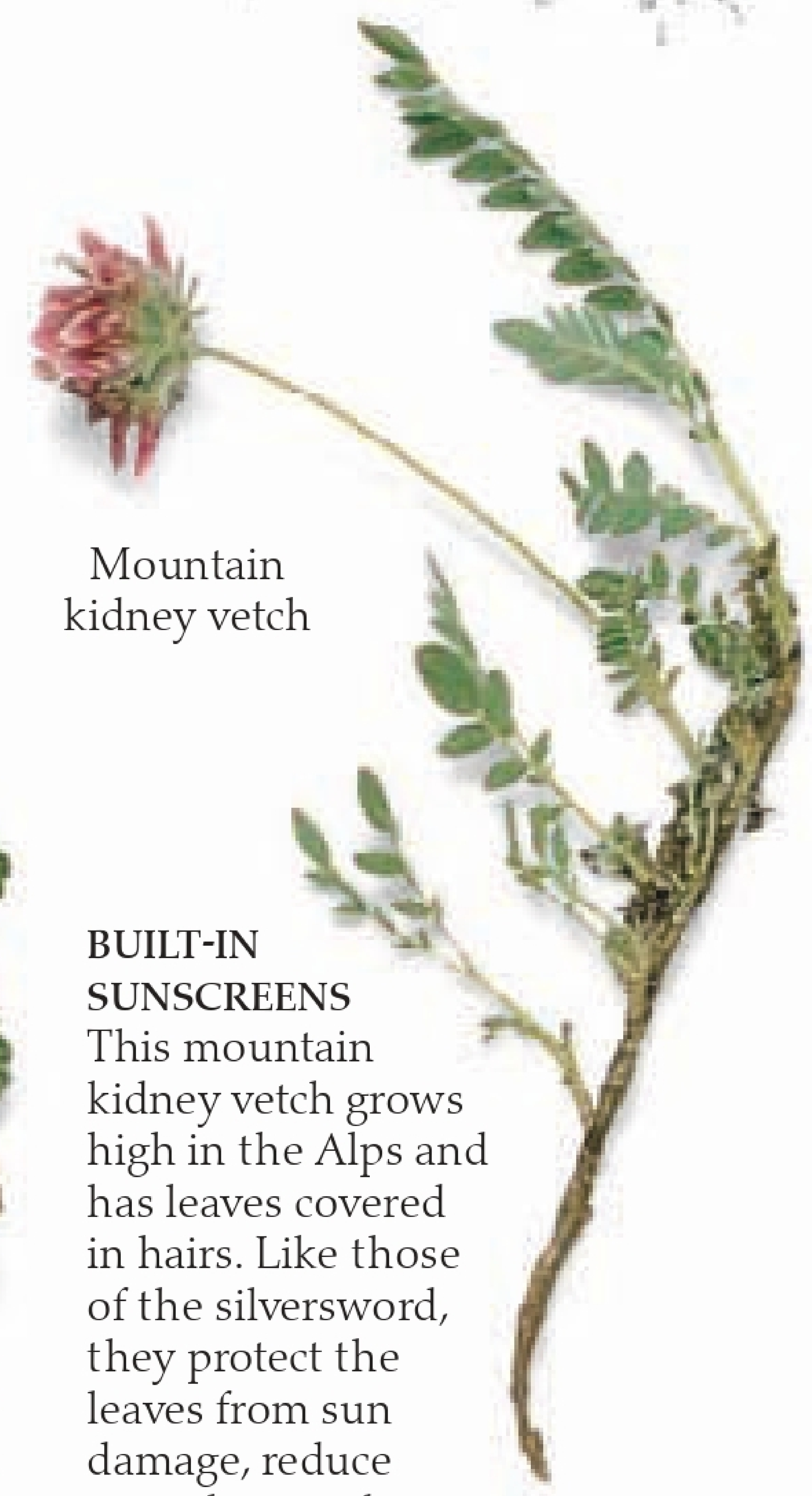
THE HIGHER THE ALTITUDE at which a plant grows, the colder the temperatures it has to endure. Very low temperatures create specific problems for plant life. Thin mountain air holds little heat, and on exposed mountainsides, strong winds create a chill factor that makes the cold even more penetrating. In addition, low rainfall and thin, frozen soils mean that water is scarce. However, many plants manage to survive despite the harsh conditions. In the Himalayas of Asia, flowering plants have been found at more than 20,000 ft (6,000 m), sheltering in hollows in the frost-shattered rock. These plants, called alpine plants, are typically small and compact, so they can survive on the high mountain peaks, or in the frozen polar regions. Alpine plants often grow in dense cushions or flattened mats, giving protection against the cold, drying wind. Upright, spreading branches would be battered by the wind, and large leaves would lose valuable heat and water.



Precariously perched tent of an alpine plant collector

TOUGH WORK
Alpine plant collectors must be fit enough to scale the heights and prepared to endure tough conditions at high altitude.

Mountain avens



Mountain kidney vetch

BUILT-IN SUNSCREENS
This mountain kidney vetch grows high in the Alps and has leaves covered in hairs. Like those of the silversword, they protect the leaves from sun damage, reduce water loss, and act as insulation.

HAIRY LEAVES
Mountain avens are plants that grow on high ground, from the Alps of Europe to the Arctic. Fine hairs on the undersides of their leaves minimize water loss and protect against the cold.

QUICK WORK
When spring comes, the mountain slopes burst into color as alpine plants begin to flower. In high mountain areas where the summers are short, these plants have to flower and produce seeds quickly before winter comes around again.

RADIATION HAZARD
The sunlight that falls on high mountaintops in the tropics is more intense than anywhere else on Earth. The silversword grows in Hawaii at altitudes of up to 15,000 ft (4,000 m). Its leaves are covered with fine white hairs that protect the plant from much of the Sun's dangerous ultraviolet radiation.

Dwarf hebe

PLANT CUSHIONS
This dwarf hebe from New Zealand is an evergreen plant with small tough leaves that can withstand sharp frost. It grows in dense cushions that trap heat, prevent wind damage, and reduce water loss. These cushions are covered in white flowers every spring.

Mazus reptans

FLAT AGAINST THE GROUND
Many alpine plants spread over the ground in the form of flat mats, keeping out of the path of icy winds. *Mazus reptans* is a mat-forming plant from the Himalayas.

Garland flower

A MINIATURE SHRUB
This alpine daphne, or garland flower, is a shrub in miniature. Larger daphnes grow at lower levels.

Alpine moltkias

SMALL LEAVES
Moltkias are members of the forget-me-not family. Unlike many of their lowland relatives, alpine moltkias have small leaves, which are better able to withstand strong mountain winds.

MOUNDS OF COLOR
Like many alpine plants, this beautiful phlox from North America has brilliantly colored flowers. They stand out against the rocky slopes and attract pollinating insects.

Alpine phlox

Rock rose

DUAL PROTECTION
Mountain rock roses are protected from the weather in two ways. The bushy plants are able to stand up to strong winds better than those with taller, more rigid stems. Their leaves and stems are covered with fine hairs that act as insulation at night.

TWO WAYS TO SPREAD
This species of storksbill lives in the high Pyrenees of Europe. It spreads both with seeds and with its creeping root system (p. 32).

Storksbill

MOUNTAIN DWARF
Many mountain plants that survive at great heights, such as this St. John's wort, are much smaller than their lowland relatives.

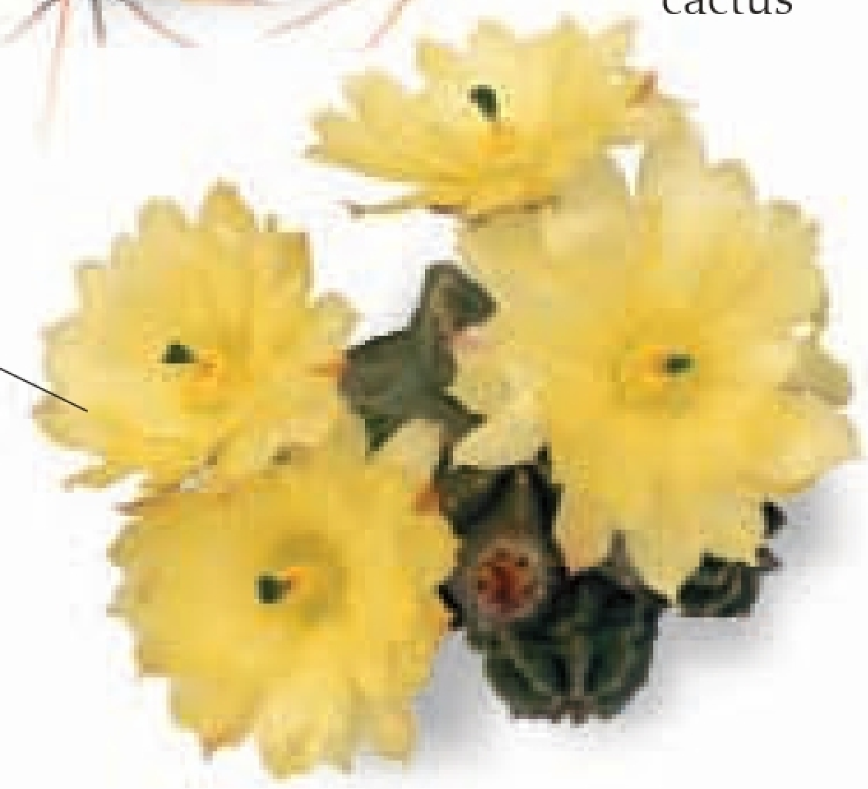
St. John's wort

Living without water

No plant can live entirely without water. But in very dry regions, where water is scarce, plants called cacti and succulents are able to survive for a number of years between rainstorms. In the world's driest places, rain often comes in irregular but heavy bursts, so the plants that live there have evolved ways of collecting as much water as possible during downpours. The water is then stored in preparation for the next drought. Many cacti and succulents have very long roots. Most of these roots grow near the surface, so that when it rains the plants can collect water from a wide area. Once the water is inside the plant, it is kept there by a number of special adaptations. Plants normally lose water from pores, called stomata, in the surface of their leaves. The plant can control these pores, and it will close them if it begins to lose too much water. Many cacti and succulents open the pores only at night, when the air is cool and less water can evaporate. Some of these plants have gotten around the problem of water loss by losing their leaves altogether.

Barrel cactus

Fish-hook cactus



Hedgehog cactus

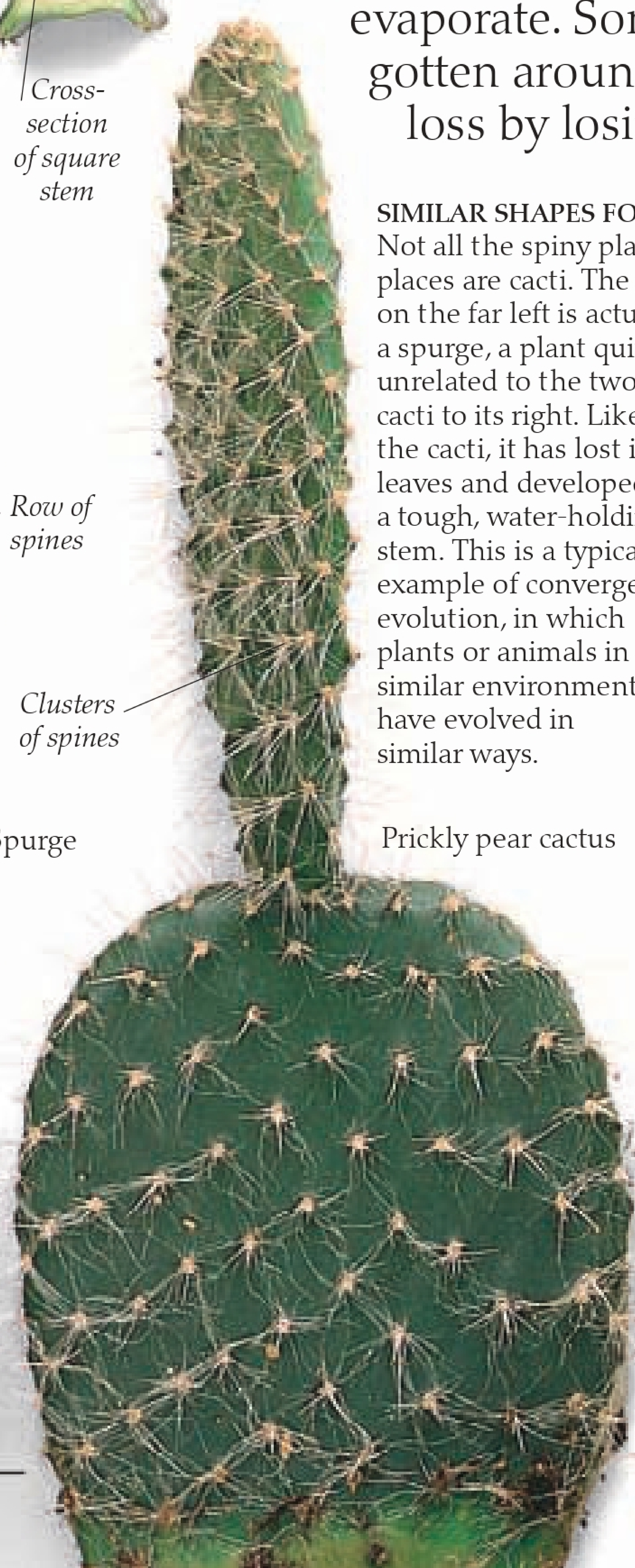
Many cacti have beautiful flowers

THE CACTUS FAMILY
Almost all true cacti come from the Americas. Because they live in very dry places, they have had to evolve strange shapes to be able to survive. Most cacti have very thick stems and thick groups of spines instead of normal leaves. These spines may protect the plant from heat and cold, as well as from attack by animals. Many cacti have ridges down their stems to allow them to expand and store water when it rains.

Row of spines

Spurge

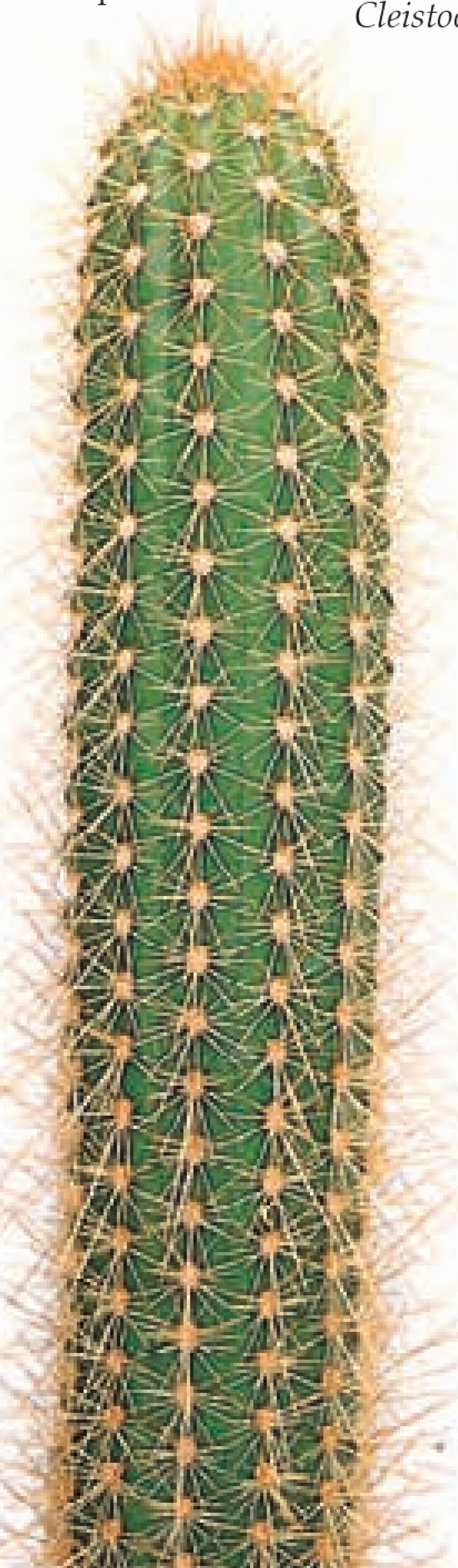
Cross-section of square stem



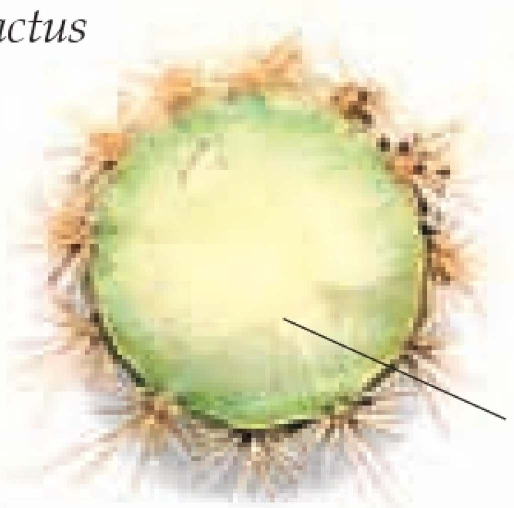
Clusters of spines

Prickly pear cactus

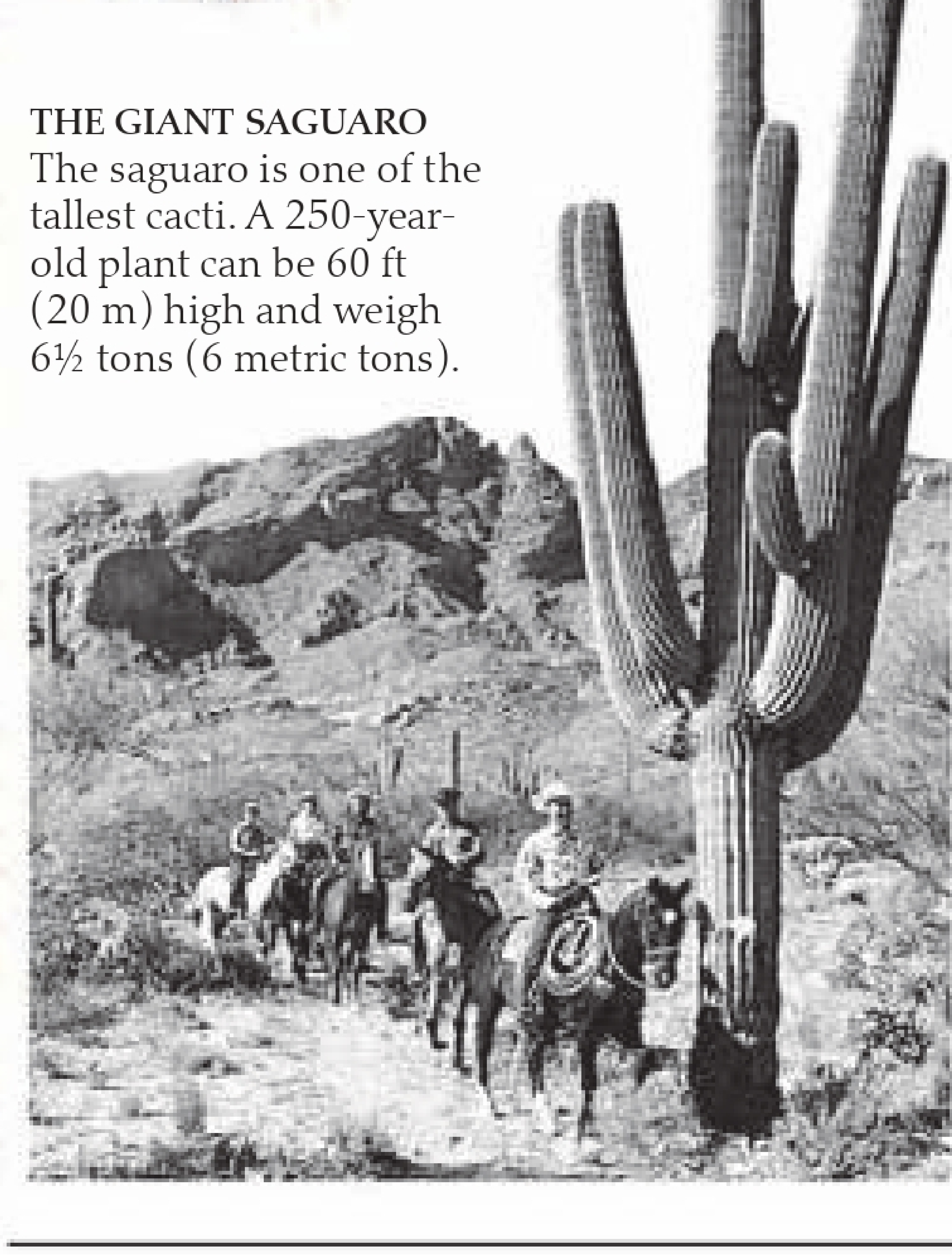
SIMILAR SHAPES FOR SIMILAR LIFESTYLES
Not all the spiny plants that live in dry places are cacti. The cactuslike plant on the far left is actually a spurge, a plant quite unrelated to the two cacti to its right. Like the cacti, it has lost its leaves and developed a tough, water-holding stem. This is a typical example of convergent evolution, in which plants or animals in similar environments have evolved in similar ways.



Cleistocactus



Cross-section of round stem



THE GIANT SAGUARO
The saguaro is one of the tallest cacti. A 250-year-old plant can be 60 ft (20 m) high and weigh 6½ tons (6 metric tons).

Succulents

Plants with fleshy leaves or stems for storing water are known as succulents. They include the group of plants called cacti. There are three main types of succulent. Stem succulents, such as cacti, store water in their stems and tend to live in the driest climates. Leaf succulents, some of which are shown on this page, store water in their leaves and grow in damper conditions. Finally, root succulents have thickened roots that serve as water reservoirs.

LEAF SUCCULENTS
Leaf succulent plants live in semidesert and also in salt marshes, where the salty conditions mean that fresh water has to be carefully conserved. Their leaves wrinkle up in prolonged dry weather. When it rains, they swell again as the plant takes in water.

LEAVES THAT WITHSTAND DROUGHT
As much as nine-tenths of the weight of a succulent leaf may be stored water. To conserve this vital store, the leaves have a waxy surface that hinders transpiration, which is the process by which leaves lose water. Some succulent leaves have a woolly surface that helps to keep the leaf cool, which in turn reduces water loss. Succulent leaves have evolved in many unrelated plant species throughout the dry regions of the world.

FLEETING FLOWERS
Many desert plants are ephemerals. This means that they germinate only after rain, and then complete their life cycle very rapidly. For a few days after rain, the desert is ablaze with their flowers. This sea of little yellow flowers is made up of thousands of sand sunflowers, which have all come into bloom at once in the Utah Desert.

MARKET IN PERU
Potatoes originated in the high Andes of South America. Many varieties of potato are still grown there, as this market scene shows.

Food from plants

PLANTS HAVE BEEN CULTIVATED as food crops for thousands of years. The earliest humans lived in nomadic groups, roaming the landscape in search of food. Eventually, these peoples settled down, and instead of collecting plant foods from the wild they began to cultivate them. When the time came to gather seeds to produce crops for the following year, they tended to take seeds from the healthiest plants. As they did this year after year, they began to produce better crop plants. Later, more deliberate efforts were made to improve crops by selecting and cultivating the strongest plants, and this process is continuing today. As farming settlements were established independently in different parts of the world, so different crops were cultivated in each place. This meant that when early travelers first visited distant continents, they found many new and exciting foods to bring home. The crops we eat today come from many different parts of the world.

KEPT IN THE DARK
If allowed to grow in the light, endive has a bitter taste. To reduce this bitterness, the plant is cut back to the ground and then allowed to regrow with almost no light. The pale, blanched leaves of the new endive shoot are far less bitter. If cultivated endive were grown entirely in the light, the plant would look very similar to wild chicory.

Wild chicory

Blanched shoot of cultivated endive

Modern corn cob

Primitive form of corn plant and cob

PRIMITIVE CORN
Corn is a cereal: like wheat and rice, it is a member of the grass family. It was first cultivated in Central America, and some primitive forms of corn can still be found growing there. As a result of selective breeding, the size and shape of the modern corn cob have been increased.

Fruits of a wild tomato, from Mexico

Wild tomato flowers

Cultivated tomato flowers are very similar

Cultivated tomatoes

Cultivated tomatoes have become much bigger through breeding

BIGGER—AND BETTER?
The tomato's wild ancestor is a red berry the size of a small grape. It is much sweeter than a modern tomato, with a stronger flavor.

GROWING IN WATER
Rice, which was cultivated in the Far East at least 5,000 years ago, forms the staple cereal diet of over one half of the world's population. It usually grows in fields of standing water, known as paddy fields.

Working in the paddy fields

Flower head of wild carrot

Wild carrot root

Cultivated carrot

EDIBLE ROOTS
The wild carrot is found all over Europe and through much of Asia, but its roots are white or only slightly colored. Only in Afghanistan is there a variety of wild carrot with orange roots. The carrot was probably first cultivated in that region, and then introduced to other parts of the world.

Wild cabbage has dark green, leathery leaves

LEAVING THE PAST BEHIND
The wild cabbage grows near the sea. It has leathery leaves, loosely arranged on a branched stem. Years of breeding have gotten rid of the plant's bitter taste and made its leaves more juicy. The shape of the plant has also changed so that, in most cultivated cabbages, the leaves are packed tightly together. In red cabbage varieties, certain natural pigments have been built up as a result of selective breeding.

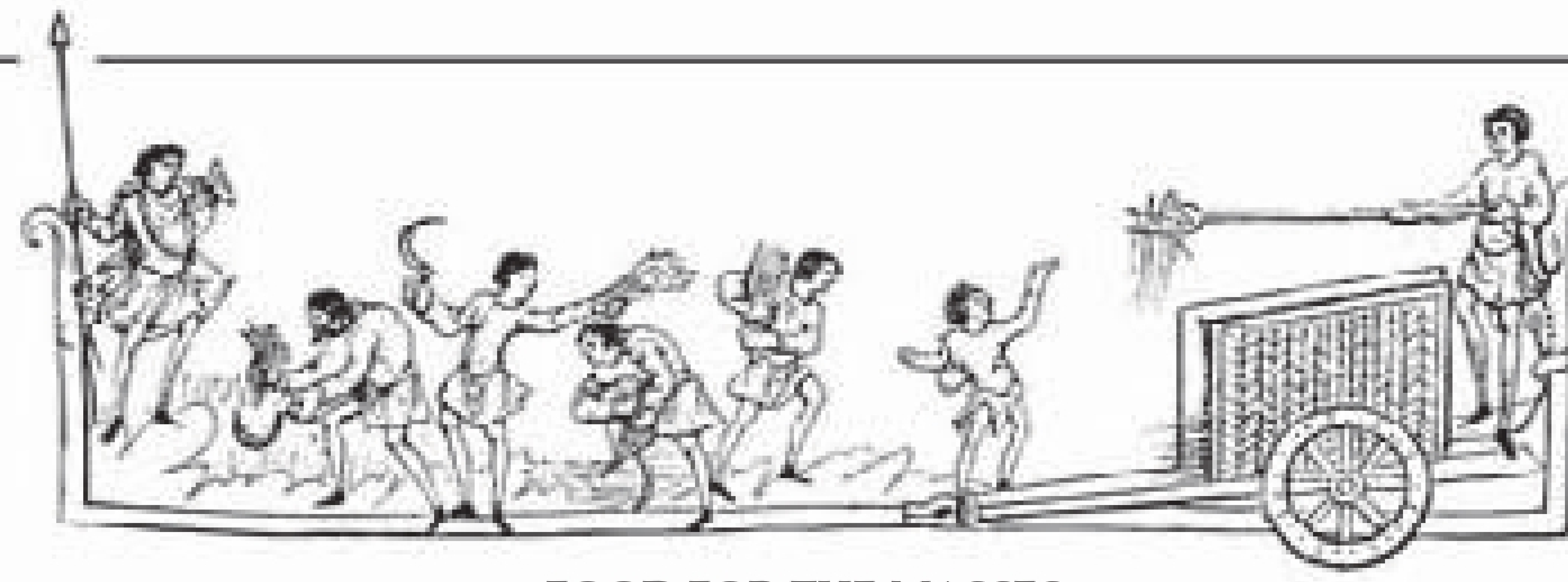
Modern cabbage

Modern red cabbage

CARROTS AND CABBAGES
This detail from a 16th-century painting by the Dutch artist Lucas Van Valkenborch proves that even 400 years ago there was a wide variety of vegetables available.

The story of wheat

Wheat has been cultivated by humans as a valuable source of food for at least 9,000 years. Grains of wheat have been found preserved in ancient Egyptian tombs, and it is known that it was the chief cereal of the ancient Greeks and Romans. The cultivation of wheat originated in the region known as the Fertile Crescent, which includes part of modern-day Israel, Turkey, Iraq, and Iran. Once a rich farming area, today much of it is desert. Wheat is now grown in most parts of the world, and the quality has improved greatly. The early, primitive species, such as einkorn and emmer, had long, thin stalks that were easily broken in bad weather. Their small grains meant that a large number of plants only produced a relatively low yield of grain. Today, as a result of extensive breeding programs, better varieties have been found that have higher yields, resist drought, and withstand disease.



FOOD FOR THE MASSES
People have grown cereals for food for thousands of years, as this picture from the 11th century shows.

CUTTING THE CORN
Wild grasses drop their ripe seeds. The first farmers selected plants that held on to the seeds, so that the grain could be harvested.

WILD EINKORN
This wild grass is probably one of the ancestors of all cultivated wheats. It has long, thin stalks and small heads and grains.

EINKORN
This early wheat species is still grown in parts of Turkey for animal feed. Its small grains are difficult to thresh.

WILD EMMER
This wild grass is the ancestor of emmer, another primitive wheat. The heads and grains are larger than those of einkorn.

EMMER
Emmer was the chief cereal in ancient Greek and Roman times. It is one of the ancestors of modern cultivated wheat varieties.

SPELT

The great leap forward for wheats came when emmer crossed, or hybridized, with wild goat grass that was growing as a weed in wheat fields. The result was spelt wheat, which is still cultivated in parts of northwest Europe.

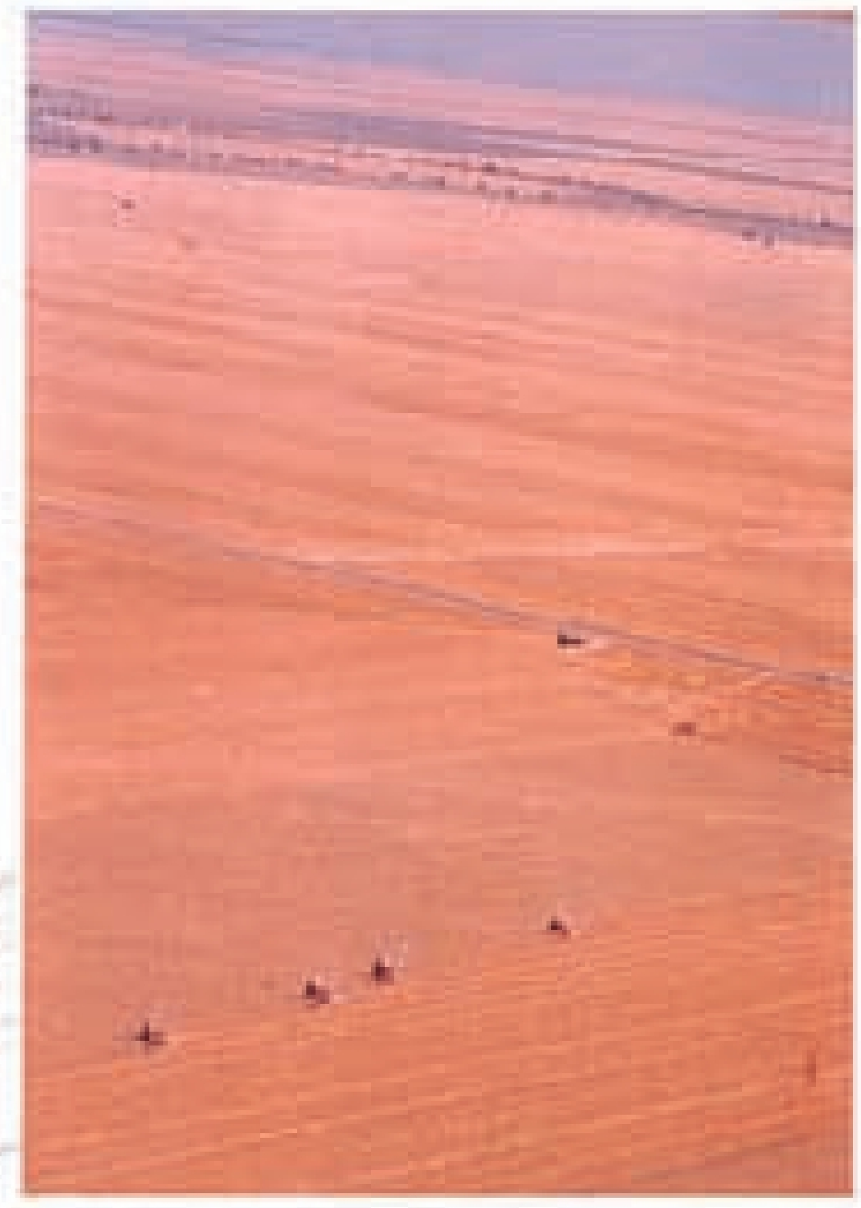
Spelt grains

The long, spiked bristles attached to scales around each grain are called awns

Durum wheat

WHEATFIELD PRAIRIE

Today's wheat is much shorter than that of a century ago. Breeders have reduced the amount of stalk, so that the plant does not bend over, making it difficult to harvest the grain. This is an important step forward for the major grain-producing countries of the world, where vast areas of wheat are grown.



Pasta shells

DURUM WHEAT

Another large-grain wheat closely related to emmer is durum, or macaroni, wheat. It is grown widely today to provide the flour for pasta and cookies. Because its gluten content is low, it does not make good bread. Modern durum wheat has bigger grains as a result of intensive breeding.

Bread wheat

Grains of bread wheat

Brown bread baked with unbleached wholewheat flour

Uncooked wholewheat flour

White bread, made from very finely ground flour that has been bleached

BREAD WHEAT

Bread wheat is also a hybrid of emmer and wild goat grass, and it is the most widely grown modern wheat. Its large grains have a high gluten content, which makes bread dough elastic and enables light, airy bread to be made.

Potions and poisons

In ancient times, plants were the main source of medicines. By trial and error, it was discovered that particular species could cure certain diseases. These plants were often grown in special gardens, and their details noted in books called herbals. Today, many plants are still used by the pharmaceutical industry. The chemicals they produce may be poisonous in large quantities, but small amounts can prove very useful in the treatment of some illnesses. The search for new medicines continues today, and every year pharmacologists examine thousands of plants from all over the world.

MANDRAKE
The mandrake root, once used in medicines, sometimes looks almost human. It was usually pulled up by a dog, because, according to an old superstition, the root would shriek as it came out of the ground. Any human who heard the noise would die.

Aloe vera

Cosmetic preparation made from aloe vera

Jojoba

COSMETIC EFFECT
Plants are often used in cosmetics for their pleasant smell, or soothing oils. Two plants that are popular in today's cosmetics are jojoba and aloe vera. Both live in dry places and contain oils that help to keep skin soft.

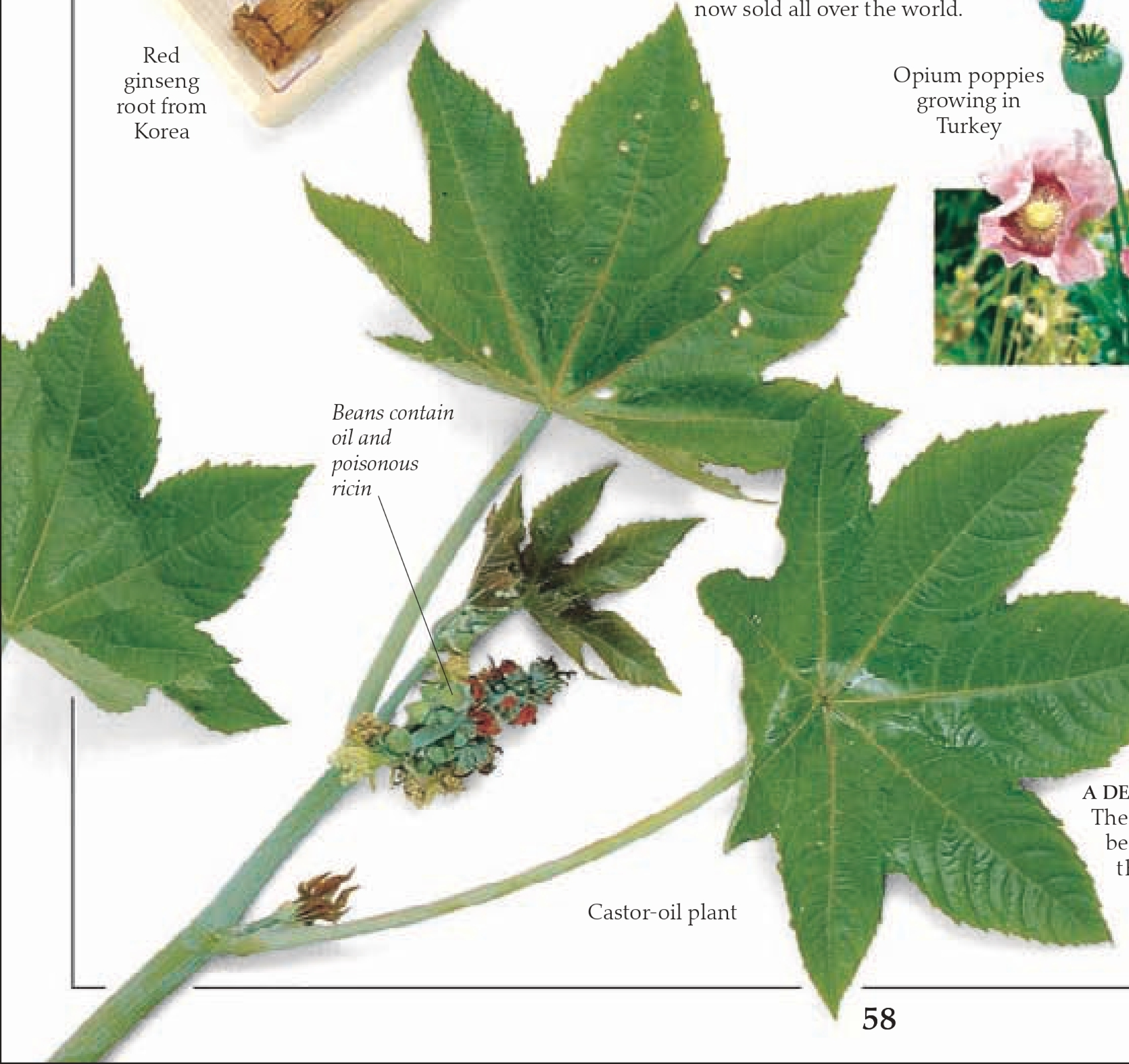
Red ginseng root from Korea

OUT OF THE EAST
In China, ginseng has been prized for about 5,000 years. The powdered root has a stimulant effect and can aid recovery from illness. Ginseng is grown commercially and is now sold all over the world.

Opium poppies growing in Turkey

THE OPIUM POPPY
For thousands of years opium poppies have been grown as a source of drugs. Raw opium is the poppy's dried sap. It oozes out of the unripe seed head after it has been scarred with a knife. Opium is used in the manufacture of morphine, codeine, and heroin—drugs that can be deadly if misused.

Detail of a page from a 12th-century herbal



Beans contain oil and poisonous ricin

Castor-oil plant

A DEADLY DOSE
The oil from the beans of the castor-oil plant has been used to purify the system since the days of the ancient Egyptians. The beans also contain ricin, one of the most potent poisons known. Ricin is so powerful that, if eaten, just one bean is enough to kill an adult.

Leaves of the dumb cane

THE DUMB CANE
The name of this plant comes from its poisonous sap. If this is swallowed, it makes the mouth swell so much that talking becomes difficult.

DRINK OR DRUG?
The mescal cactus contains a hallucinogenic substance called mescaline, which is used in the religious rituals of certain Mexican Indian tribes. Confusingly, the drink mescal (or mezcal) is not derived from the mescal cactus, but from the agave plant, which is also native to Mexico.

Mescal cactus

Mescal, a drink made from the agave plant

DEADLY BERRIES
The drug atropine, which is used in eye surgery and to treat stomach complaints, is derived from a very poisonous plant called belladonna, or deadly nightshade.

Belladonna, or deadly nightshade

FROM COCA TO COCAINE
Many centuries ago, South American Indians discovered that chewing the leaves of the coca plant dulled pain and prevented tiredness. Coca leaves contain the drug cocaine. Although a valuable anesthetic, cocaine can be dangerously addictive.

Coca leaves for sale

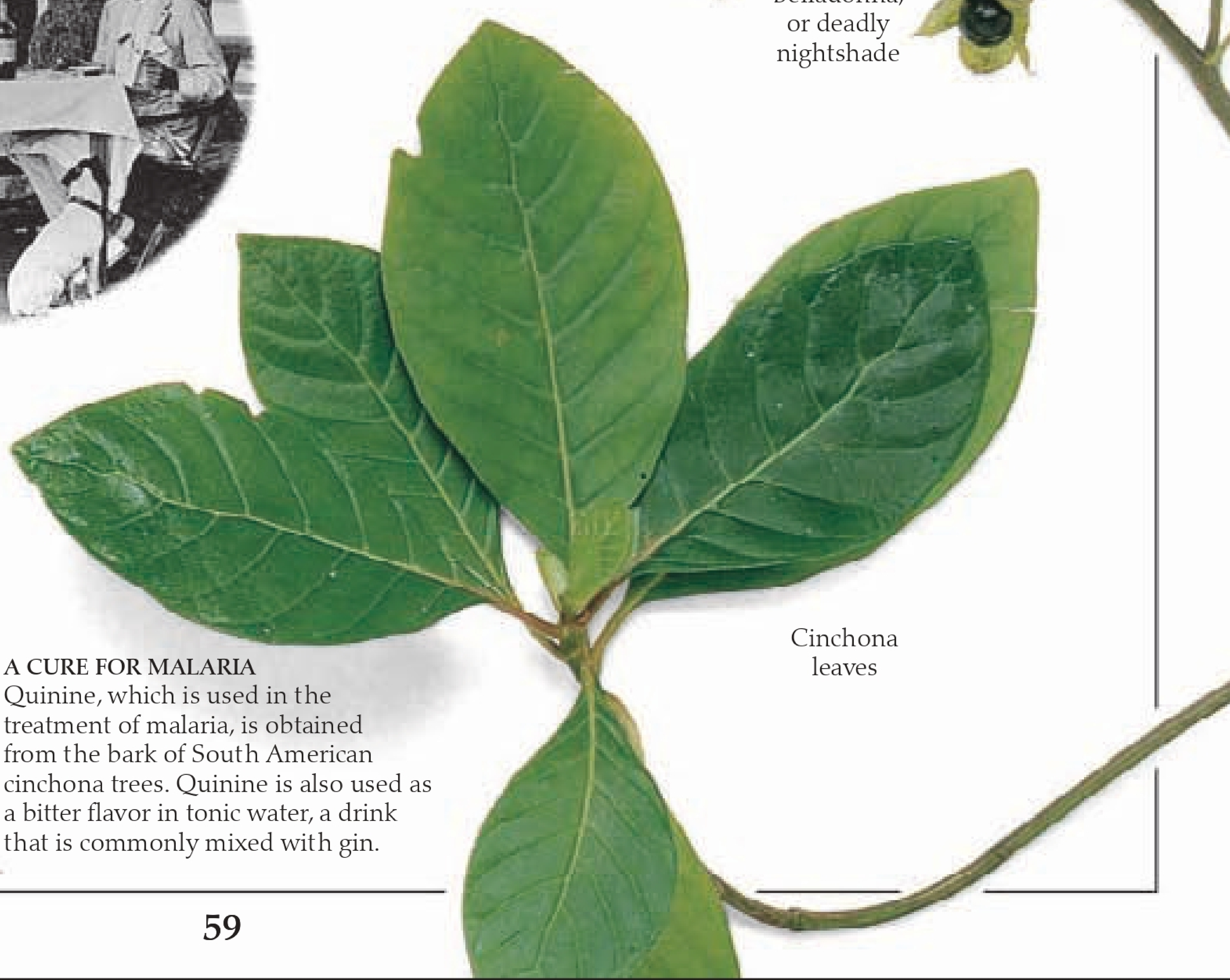
Coca leaves

Drinking gin and tonic water in India, at the end of the 19th century

Foxglove

HELP FOR THE HEART
The leaves of the foxglove contain a substance that is used to treat heart conditions. In large doses, it produces palpitations and dizziness, but in small doses, it helps the heart to beat more slowly and strongly.

A CURE FOR MALARIA
Quinine, which is used in the treatment of malaria, is obtained from the bark of South American cinchona trees. Quinine is also used as a bitter flavor in tonic water, a drink that is commonly mixed with gin.



Cinchona leaves

The plant collectors

This plant is named after its discoverer, Joseph Pitton de Tournefort

Scutellaria tournefortia

ROYAL MISSION
Joseph Pitton de Tournefort (1656–1708) was a botanist who was sent to the eastern Mediterranean by the French king Louis XIV. He returned with the specimens and seeds of over a thousand plants, many of which became garden favorites.

Many of the plants that have become common in gardens all over the world are, in fact, very far from home. Most fuchsias, for example, come originally from South America, wisteria from China and Japan, many azaleas from the Himalayas in Asia, and tulips from western and central Asia. These are just some of the thousands of plants that have been carried across the world by plant collectors. Plant collecting had its heyday in the 19th and early 20th centuries, as intrepid botanists traveled farther and farther afield in search of unknown plants. Some collectors experienced great hardships on their voyages to distant places—they were shot at, caught in earthquakes, and attacked by wild animals. But despite all such adversities, the lure of making new discoveries spurred them on to explore some of the world's most remote and dangerous places.

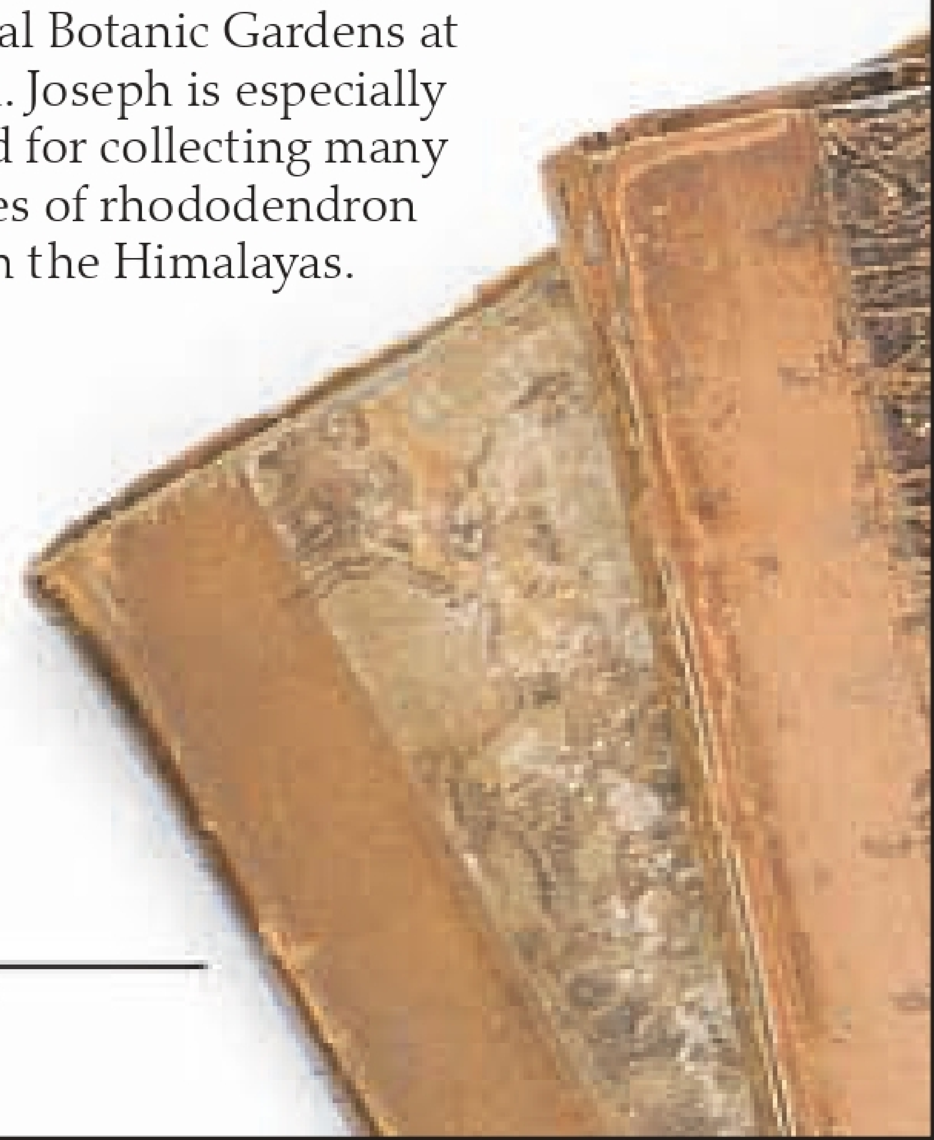
A 19th-century plant collector with his collecting case, or vasculum

GOING EAST
The picture above shows botanists on a plant-collecting expedition to China in the 1920s. This region of the world has been of great interest to botanists for many years, and expeditions made there today still discover new plant species. The photograph on the right shows a botanist at work on a modern plant-collecting expedition.

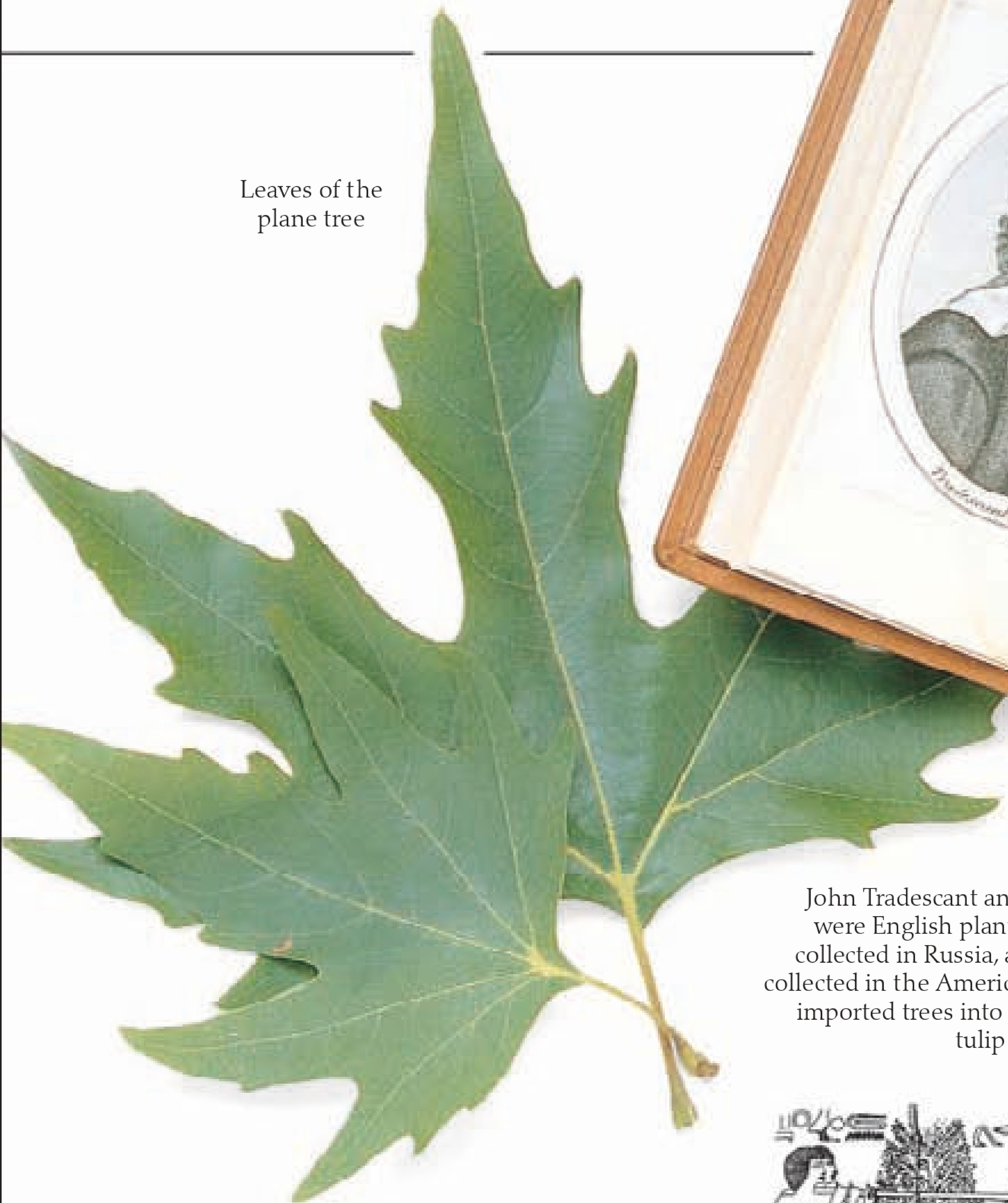
A 19th-century vasculum containing *Sarcococca hookeriana*, a species of sweet box

Sarcococca hookeriana *is named after the Hookers*

FATHER AND SON
William Hooker (1785–1865) and his son Joseph (1817–1911) were both passionately interested in plants. William Hooker became the first director of The Royal Botanic Gardens at Kew in England. Joseph is especially remembered for collecting many species of rhododendron in the Himalayas.



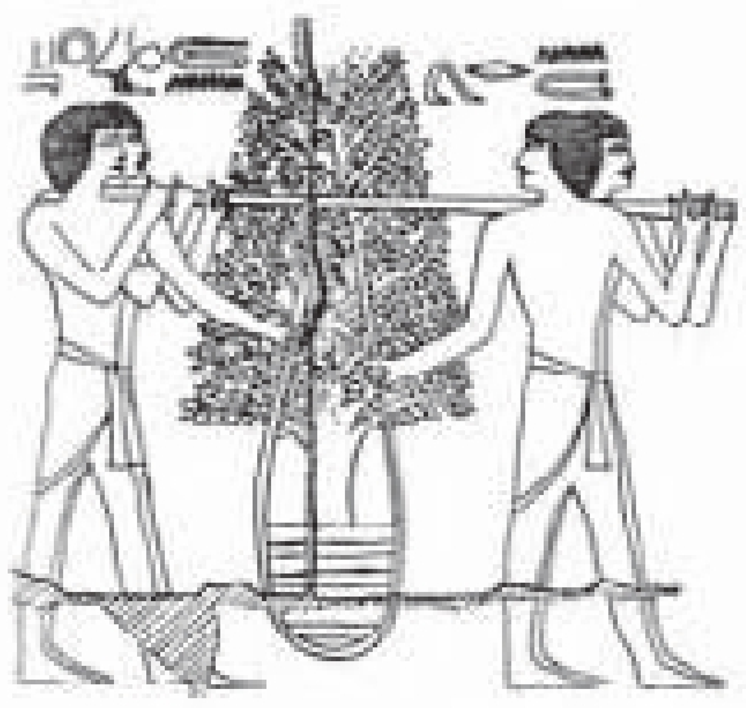
Leaves of the plane tree



Tradescant father and son

GOING WEST
John Tradescant and his son, also named John, were English plantsmen. Tradescant the Elder collected in Russia, and Tradescant the Younger collected in the Americas. The younger Tradescant imported trees into Europe. These included the tulip tree and the western plane.

Tradescantia—a border plant named after John Tradescant the Elder



FIT FOR ROYALTY
Plant collecting is an ancient pursuit. This Egyptian mural shows the earliest recorded expedition, which took place in 1495 BCE. Collectors brought back frankincense trees for Queen Hatshepsut from the Horn of Africa.

Beautifully preserved botanical reference books

THE EMPRESS COLLECTOR
Empress Josephine, the wife of Napoleon, created a unique garden at her house at Malmaison, with roses brought from all around the world. At the time, France was at war with Britain, but ships carrying the imperial roses were allowed safe passage.

Looking at plants

Plant collectors

THERE ARE TWO TYPES of plant collection—living plants and preserved specimens. A herbarium is a collection of preserved specimens, usually pressed, that can be examined by botanists. Collections of living plants are equally important and sometimes ensure that rare plant species do not die out. Making your own collection of flowers and pressing them is a good way to learn about plants. However, you should not pick flowers that are growing wild in the countryside, since this prevents them from producing seeds. All wild flower species are protected by law, and you must not uproot them without receiving permission from the person who owns the land. If you want to try to grow your own plants, you can collect small amounts of seed, or you can buy wild flower seeds produced by plants that have been raised in nurseries. Growing your own plants gives you a chance to study them without harming plants in the wild.

Herbarium specimen sheet

Box containing dried specimen

Preserving bottle

Plant press

BOTANIST'S COLLECTING EQUIPMENT
When collecting plants for the herbarium, a specimen is pressed and then mounted on a herbarium sheet with a label saying where and when it was found. The herbarium sheet can then be consulted by botanists wishing to study the plant in detail.

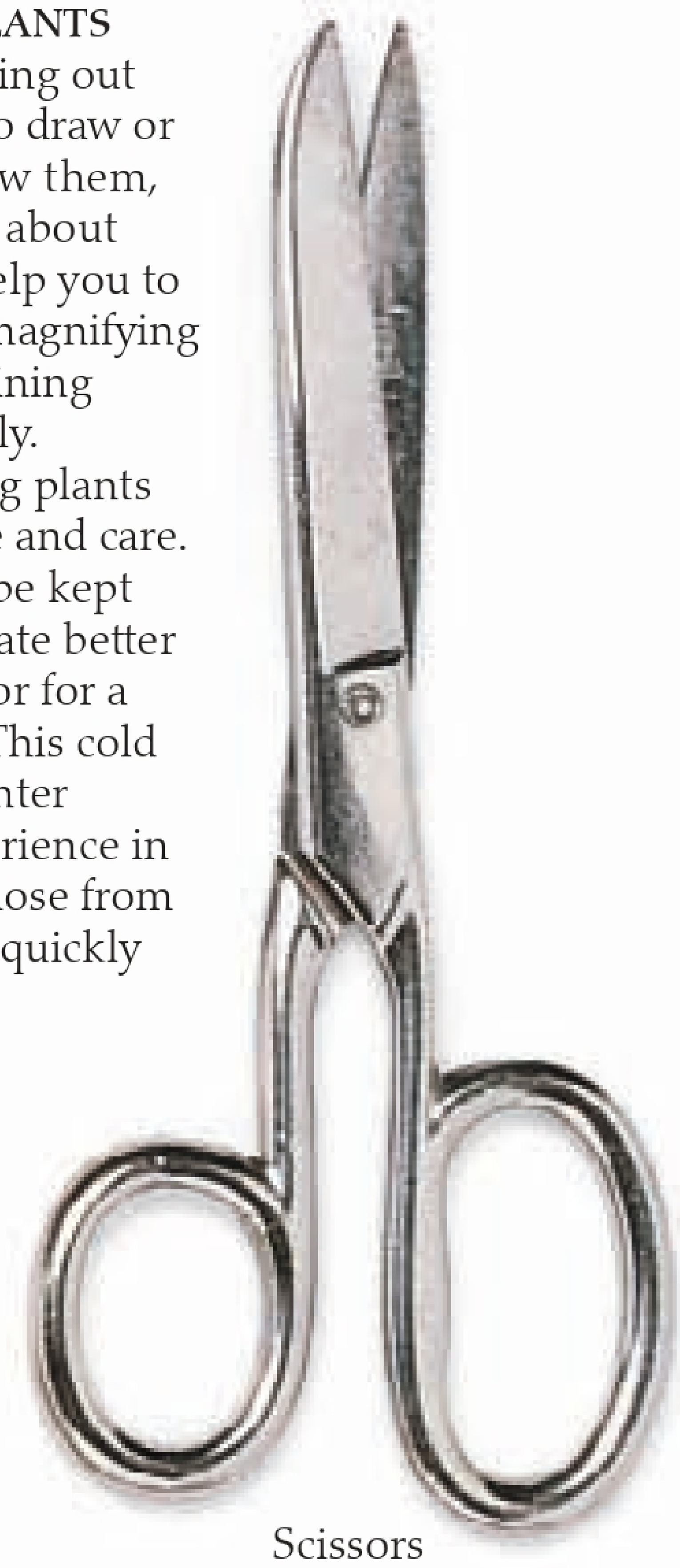
Pruning shears

Trowel

Sketch pad

Magnifying glass

LEARNING MORE ABOUT PLANTS
One of the best ways of finding out more about wild flowers is to draw or photograph them. If you draw them, you will notice many details about their structure, which will help you to identify the plant family. A magnifying glass is very useful for examining leaves and petals more closely. Collecting seeds and growing plants from them requires patience and care. Stored seeds should always be kept dry. Many seeds will germinate better if they are left in a refrigerator for a few weeks before planting. This cold period simulates the low winter temperatures they may experience in the wild. Large seeds, like those from sweet peas, germinate more quickly if they are first scratched, or scarified, with sandpaper.



Scissors

Camera

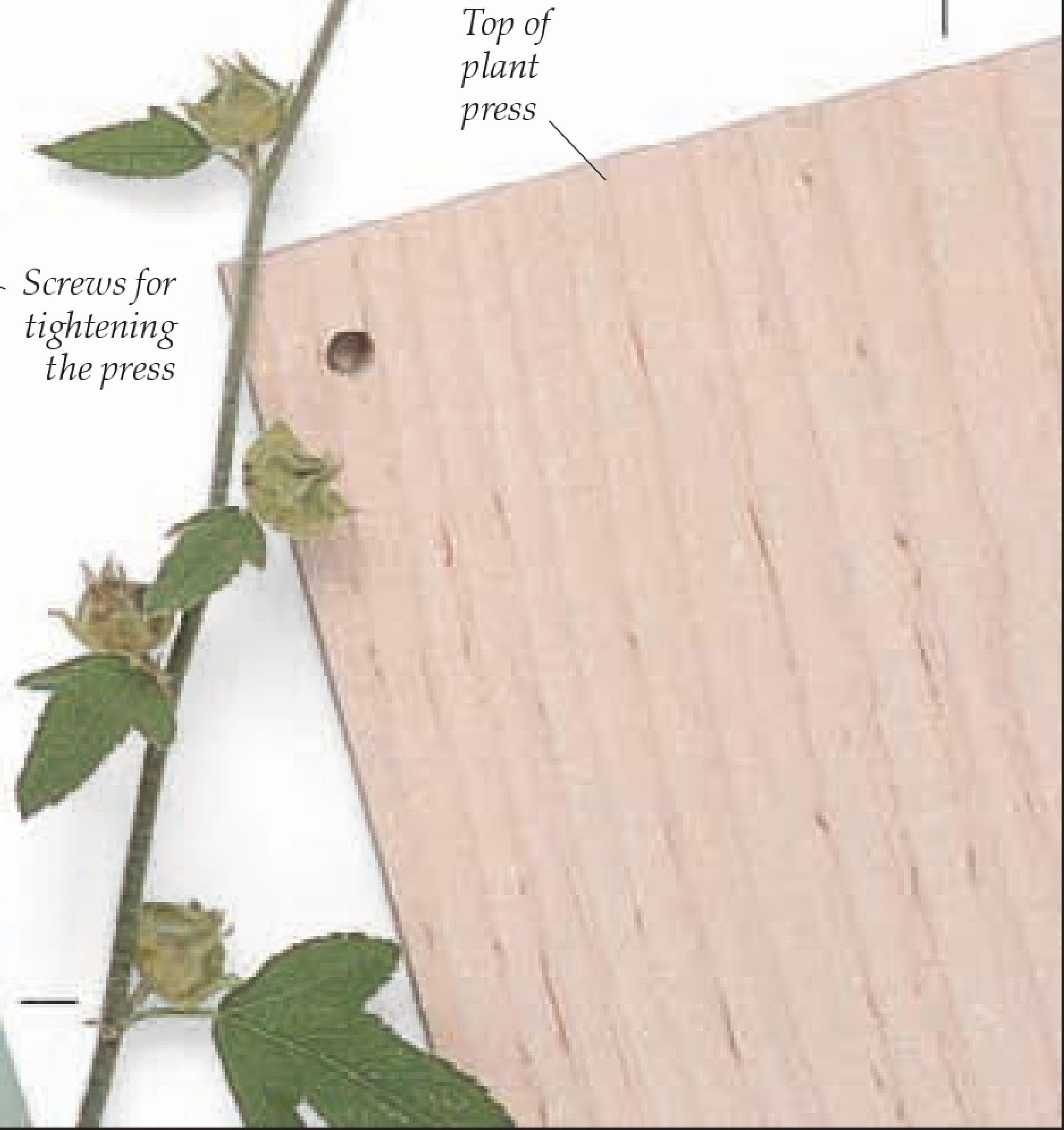
Envelopes for collecting seeds

PRESERVING SPECIMENS
Plants can be pressed with a simple plant press. The specimens are laid between two sheets of absorbent paper, which should be changed for dry sheets every day or so. It can take several weeks for specimens to dry out.

Base of plant press

Simple plant press

Screws for tightening the press



Top of plant press

Did you know?

AMAZING FACTS

Bristlecone pine tree

The oldest individual living plant (as opposed to a clump) is thought to be a bristlecone pine (*Pinus longaeva*). Named Methusaleh, it is currently 4,900 years old. It lives in the White Mountains of California, but its exact location is kept secret to protect it from harm.

The orchid family has more species than any other flowering plant, with 25,000–30,000 species recognized, mostly in tropical regions. Orchids are found in every continent except for Antarctica, inhabiting just about every type of environment, except for extreme deserts and salt water.

Arctic lupine

The oldest seed known to botany comes from the North American Arctic lupine plant and is thought to be about 10,000 years old. The tendency of lupine seeds to be naturally preserved by the cold gave scientists the idea to place seeds in cold storage as stock for the future.

The fynbos, or evergreen bushland, of the Cape region in South Africa contains one of the world's most dense concentrations of plant species within a small area. The eastern and northern coasts around Cape Town are home to an amazing range of aloes, proteas, and ericas. There are an estimated 6,500 plant species in this tiny region. This is almost as many as in the whole of the continent of Europe.

Sphagnum moss, which is found in bogs and contributes to the formation of peat, can soak up more than 25 times its own dry weight in moisture.

As plants get smaller we know less about them. Scientists estimate that they have identified 85–90 percent of flowering plants, but only about 5 percent of the world's microscopic organisms.

The largest fruit is the pumpkin, which can weigh up to 1,130 lb (513 kg). Its close rival is the squash, which has been known to grow to 893 lb (405 kg).

The main ingredient in chocolate is the bean of the cacao tree, which grows in the rain forests of South America.

Proteas

Fossils of the still-existing gingko tree (*Gingko biloba*) date back some 160 million years. It first appeared at the time of the dinosaurs, during the Jurassic period. Today, extract from the bark and root of the tree is considered to have medicinal benefits for humans. The seed kernel of the tree is a delicacy in China.

The raffia palm (*Raffia ruffia*) of Madagascar and Africa's tropical eastern coast has the world's largest leaves, measuring up to 65 ft (20 m) in length.

The banyan tree (*Ficus benghalensis*) has aerial roots that grow down from the tree's branches and eventually form new trunks. In this way, the banyan grows both upward and downward.

Japan greatly values the flower of the chrysanthemum and includes its emblem on the national flag. The country has dedicated a whole day to the flower, September 9, and the *feng shui* tradition teaches that the chrysanthemum brings laughter and happiness to a home.

Tulips were originally native to Turkey, Iran, Syria, and parts of Asia, before being brought to Europe by traveling merchants in the 16th century. The Dutch were the first European nation to cultivate tulips, doing so in 1593. By 1633, the Dutch upper classes were so gripped by tulip mania that individual bulbs were changing hands for vast amounts of money.

A plant called St. Mary's bean, from Central America, has the greatest known range for drifting seeds. Its seeds have been washed up in the Marshall Islands, in the Pacific Ocean, and also on the coast of Norway—places that are 15,000 miles (24,150 km) apart.

Orchid

QUESTIONS AND ANSWERS

Red cherry fruits

Q Why are the fruits of the cherry plant red?

A The fruits of the cherry plant are bright red in color to attract birds to eat the fruits. The cherry fruits contain seeds that have a hard protective covering. This ensures that when the seeds are eaten by birds they pass unharmed through the digestive system of the creatures. In this way, the seeds are safely spread, and the plant guarantees the survival of its offspring. Plants pollinated by insects are rarely red because insects, with the exception of butterflies, cannot see the color red.

Q Which plant is considered to be the most bizarre of all?

A *Welwitschia mirabilis,* also known as the tumboa, from the Namib Desert in Africa, is one of the strangest plants in the world. Known to live for up to 2,000 years, it has a stumpy stem and just two straplike leaves, which grow nonstop throughout its life. As the plant ages, its leaves become twisted and gnarled, and they eventually can be many yards long. The leaves are tough and woody—an adaptation that helps to stop them from being eaten, or drying out. *Welwitschia* survives in a region where there is little rain, but where fog rolls in from the sea. The plant's leaves gather moisture from the fog, helping it to survive. *Welwitschia* does not grow flowers, but produces seeds in cones.

Q What is the richest plant region of the world?

A South America, which holds an estimated 90,000 species, is the world's richest plant region. Brazil is the country with the greatest known number of plant species, at 56,000, followed by Colombia, with 35,000 species. Mexico, Venezuela, Ecuador, Bolivia, and Peru are not far behind. The proliferation of plant species in this part of the world is thought to be due to the moist habitat associated with its tropical rainforests, as well as the relatively recent arrival of humans.

Q Why do some tree leaves change color in autumn?

A As the days become colder and shorter, chlorophyll, the green pigment in the leaves, breaks down and flows back into the tree. Meanwhile, waste products, such as tannins, pass out into the leaves. This chemical change produces browns and reds in the colors of the leaves as they die. Trees that lose their leaves are said to be deciduous.

Record Breakers

Smallest plant

• The world's smallest flowering plant is duckweed, (*Wolffia angusta*). A tablespoon can hold more than 100,000 plants, with each measuring only $\frac{1}{30}$ in (0.8 mm) long and $\frac{1}{60}$ in (0.4 mm) wide.

Largest seed

• The largest seed produced by any plant is that of the coco-de-mer (*Lodoicea maldivica*), from the Seychelles. This palm, also known as the double coconut tree, produces seeds that weigh up to 50 lb (23 kg) and take up to 10 years to grow into a tree.

Tallest tree

• The Mendocino coast redwood (*Sequoia sempervirens*) found in California, is the world's tallest tree, reaching a maximum height of $367\frac{1}{2}$ ft (112.01 m).

Duckweed

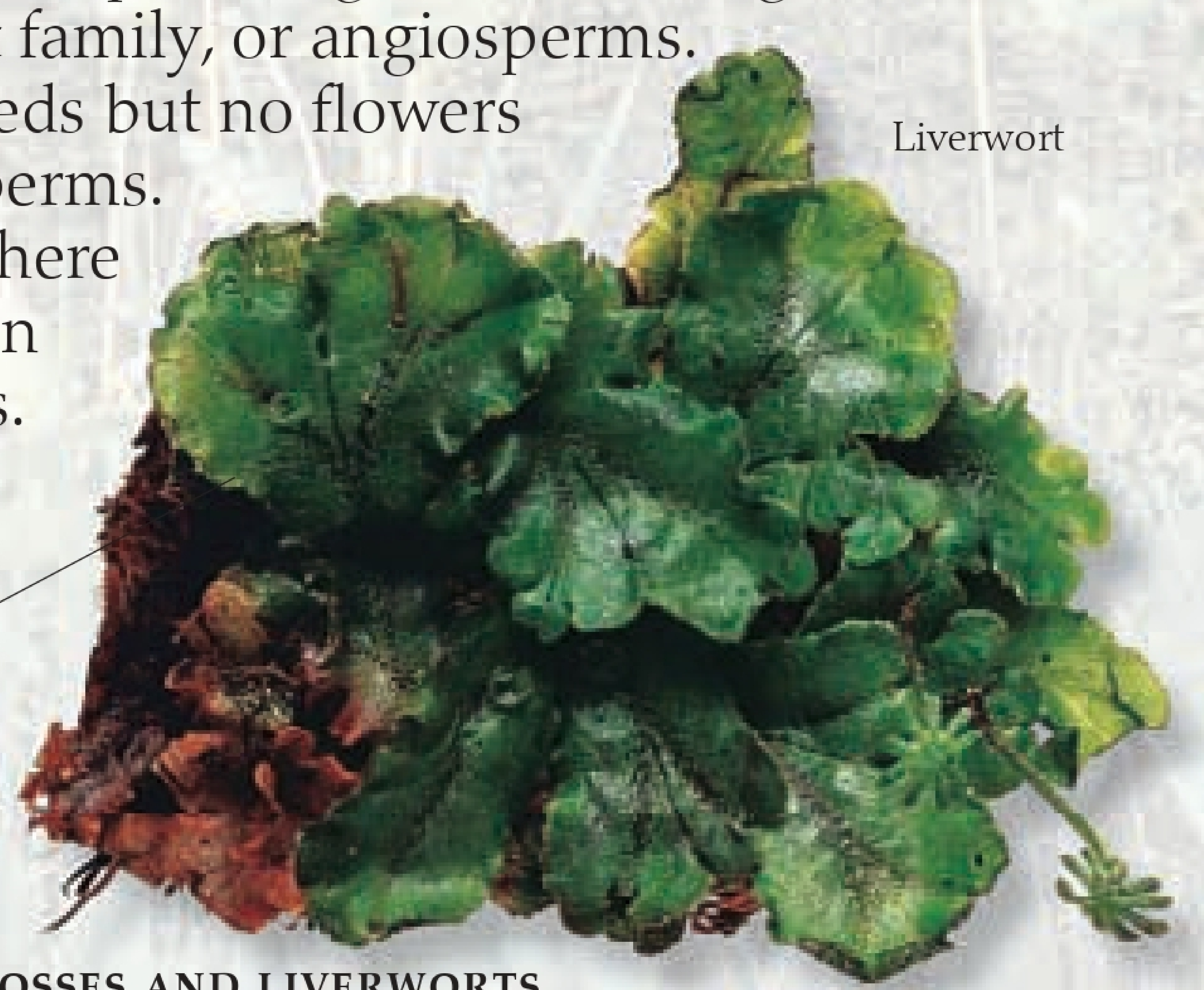
Weltwitschia mirabilis

Plant classification

THE PLANT KINGDOM is divided into different groups and contains about 400,000 separate species that we know about. The majority of plant organisms belong to the flowering plant family, or angiosperms. Plants that have seeds but no flowers are called gymnosperms. The groups shown here cover all of the main plant classifications.

Gingko

Liverwort



Most liverworts have leaves, but some are flat and leafless

Gingko

The gingko, or maidenhair, tree is native to China. A gymnosperm, it is related to conifers, but it has many unusual features, which is why it is classified in a group of its own. Unlike most conifers, gingkos are deciduous and have fan-shaped leaves.

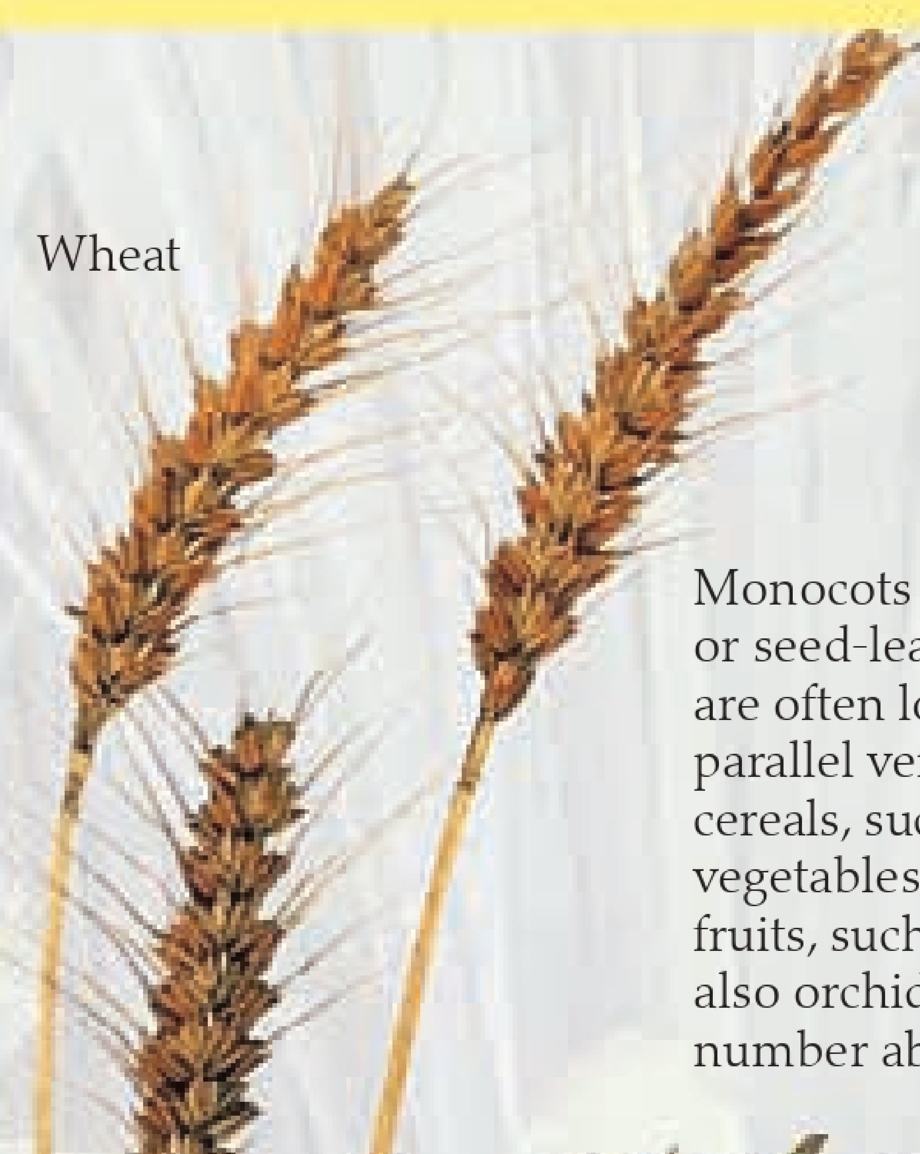
Mosses and liverworts

Mosses and liverworts belong to a group called the bryophytes, which number 14,000 species. These small plants usually grow in shaded, damp places. They first appeared around 425 million years ago, and they contributed to the formation of coal and peat.

FLOWERING PLANTS

Flowering plants, or angiosperms, constitute about 250,000 species—the vast majority of plants. A flower is a specialized part of the plant that develops into a fruit, which contains one or more seeds housed in ovaries. These seeds must be pollinated and dispersed to ensure the continuation of each species. There are two types of flowering plant: monocots and dicots.

Wheat



Monocots have a single cotyledon, or seed-leaf. Their adult leaves are often long and narrow, with parallel veins. Monocots include cereals, such as wheat, some vegetables, such as leeks, some fruits, such as pineapples, and also orchids and lilies. They number about 55,000 species.

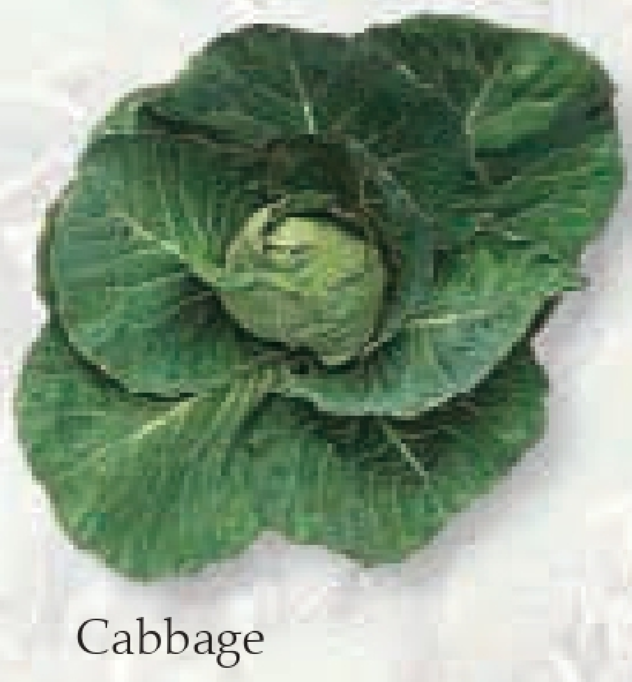
Pineapple

Leek

Dicots are plants whose seeds have two cotyledons, or seed-leaves. Their adult leaves usually have a network of veins around a central midrib. Dicots total at least 200,000 species, and they include most shrubs, and all the world's broadleaved trees.

Rose

Dicot plants often have woody stems

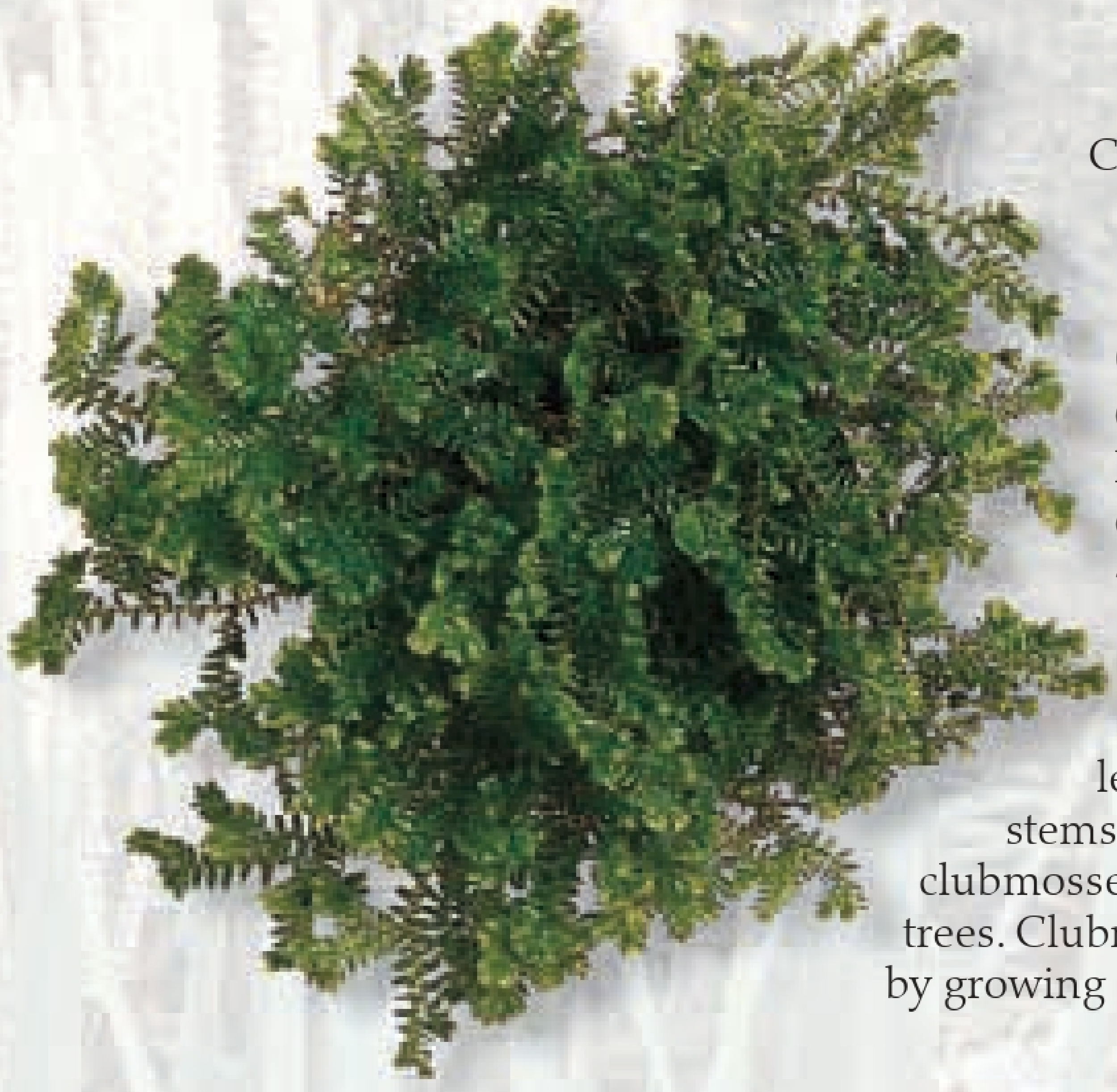


Cabbage

Cactus

Ferns

Also known as pteridophytes, ferns include around 12,000 species and thrive in damp environments, such as forests. Fern leaves are called fronds, and they carry spores on their underside. These spores produce tiny plants that reproduce in turn, giving rise to the next generation of adult ferns.



Clubmoss

Clubmosses

Clubmosses, or lycopodophytes, existed as far back as 430 million years ago. Today's clubmosses are small, with overlapping leaves and creeping stems, but some prehistoric clubmosses grew into giant trees. Clubmosses reproduce by growing spores.

Conifers

This gymnosperm group of about 550 species comprises mostly large evergreen trees. Conifers can photosynthesize even in winter, and they are often characterized by leaves shaped like needles. This group includes pines, firs, spruces, cedars, cypresses, and yews.

Pine

Cycads

Cycads are gymnosperms that grow in tropical regions. Despite being similar in appearance to palms, they are not related to them. Cycads were abundant in the Jurassic Period (208–146 million years ago), but there are now just 100 species left. Their attractive leaves make them popular garden plants.

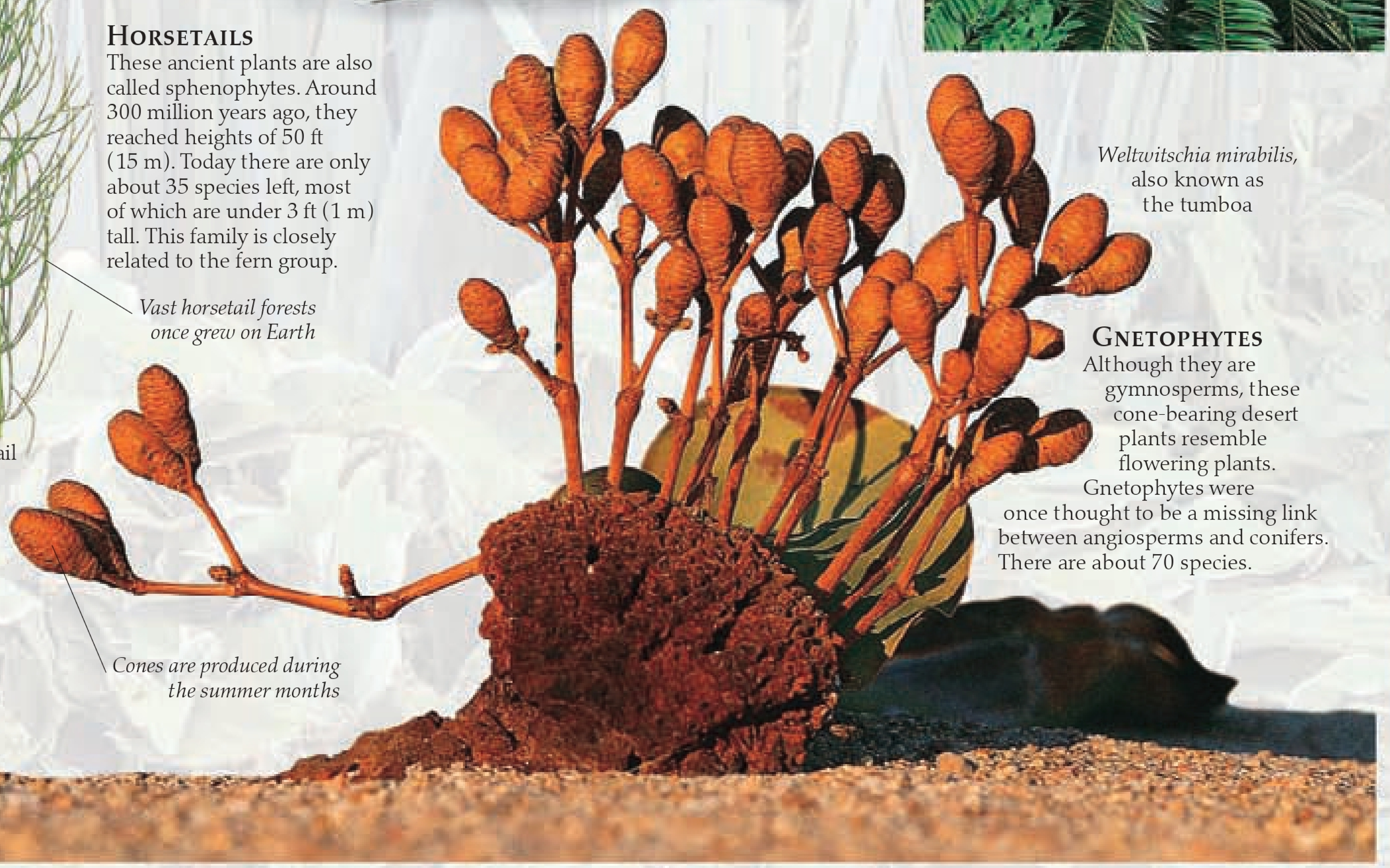
Cycad

Vast horsetail forests once grew on Earth

Horsetail

Horsetails

These ancient plants are also called sphenophytes. Around 300 million years ago, they reached heights of 50 ft (15 m). Today there are only about 35 species left, most of which are under 3 ft (1 m) tall. This family is closely related to the fern group.



Weltwitschia mirabilis, also known as the tumboa

Cones are produced during the summer months

Gnetophytes

Although they are gymnosperms, these cone-bearing desert plants resemble flowering plants. Gnetophytes were once thought to be a missing link between angiosperms and conifers. There are about 70 species.

Find out more

IF YOU WOULD LIKE TO find out more about plants, you won't have to search far. Indeed, you only have to look around you. Go exploring in your own garden or start growing a window box. Armed with a plant identification handbook, take a walk in your local park or nature preserve, where you will find plenty of specimens to admire and study. For more exotic species and a wealth of information, visit a botanical garden, or to check out ancient plant fossils, take a trip to a natural history museum. Flower markets can also be an interesting and colorful experience.

BOTANICAL GARDENS
A botanical garden is dedicated to plants from around the world. Rare and exotic species are cultivated, often in specially controlled environments, such as greenhouses. Desert plants, for example, must be kept in a hot, dry climate for survival.

If an area of land is privately owned, always seek permission to visit from the owner

Wild flowers should not be plucked, since this disturbs the natural environment

GO WILD
To see plants in a completely natural setting, just head for your local nature preserve (bring an adult along). Spring is a good time to observe budding flowers and new shoots. Few sights compare to a meadow in midsummer bloom with wildflowers.

This garden pansy will lose some of its color as it dries

Write the name of the plant and the date it was picked on the sheet of paper

COLLECTING DRIED FLOWERS
Pick a flower in full bloom. Detach the flower head and leaves and place them flat on a sheet of blotting paper. Fold and enclose the sheet between the pages of a heavy book, and leave the flower to dry out for a few weeks.

Places to visit

MISSOURI BOTANICAL GARDEN, ST. LOUIS, MISSOURI
Features a variety of themed gardens, including the largest Japanese garden in North America, plus the Climatron, the world's first geodesic dome greenhouse.

NEW ORLEANS BOTANICAL GARDEN, NEW ORLEANS, LOUISIANA
An Art Deco botanical garden focusing on the plants of the Gulf South.

DESERT BOTANICAL GARDEN, PHOENIX, ARIZONA
Plants of the desert are the centerpiece here. Visit Plants and People of the Sonoran Trail, where visitors can twist agave fibers into twine, and four other trails.

NEW YORK BOTANICAL GARDEN, BRONX, NEW YORK
Features a Victorian-era greenhouse, the Enid A. Haupt Conversatory, and a children's garden.

ORNAMENTAL BUNCHES
A bouquet of flowers doesn't have to fade away. Its beauty can be preserved by taking it out of water and keeping it in a safe place until each stem has dried out. Tie the bouquet with a ribbon and display it in a vase or on the wall.

This bunch of dried flowers was purchased at a flower market

WOODLAND WALKS
There are many official countryside walks that choose specific routes best suited to the time of year. The organized walk below follows a path that takes ramblers through the first colorful crop of springtime bluebells.

IN YOUR OWN BACKYARD
If you have a yard, this is the best place to find out more about plants. Using a notebook, you can log the growth and development of various species through the seasons. You can also grow your own plants.

ROOM WITH A VIEW
If you don't have access to a yard, window boxes make very rewarding miniature gardens. Flowers and herbs can be grown in any container and placed on a window ledge. Another way to grow plants outside is to cut an opening in a large bag of compost and use it as a soil bed.

Sunflower seeds ideally should be planted in May

USEFUL WEBSITES

- The USDA's extensive PLANTS Database: **www.plants.usda.gov**
- Homepage of the Lady Bird Johnson Wildflower Center, featuring a native plant database: **www.wildflower.org**
- A kid-friendly look at how plants work: **www.biology4kids.com/files/plants_main.html**
- An introduction to plant biology from the Missouri Botanical Garden: **www.mbgnet.net/bioplants/**

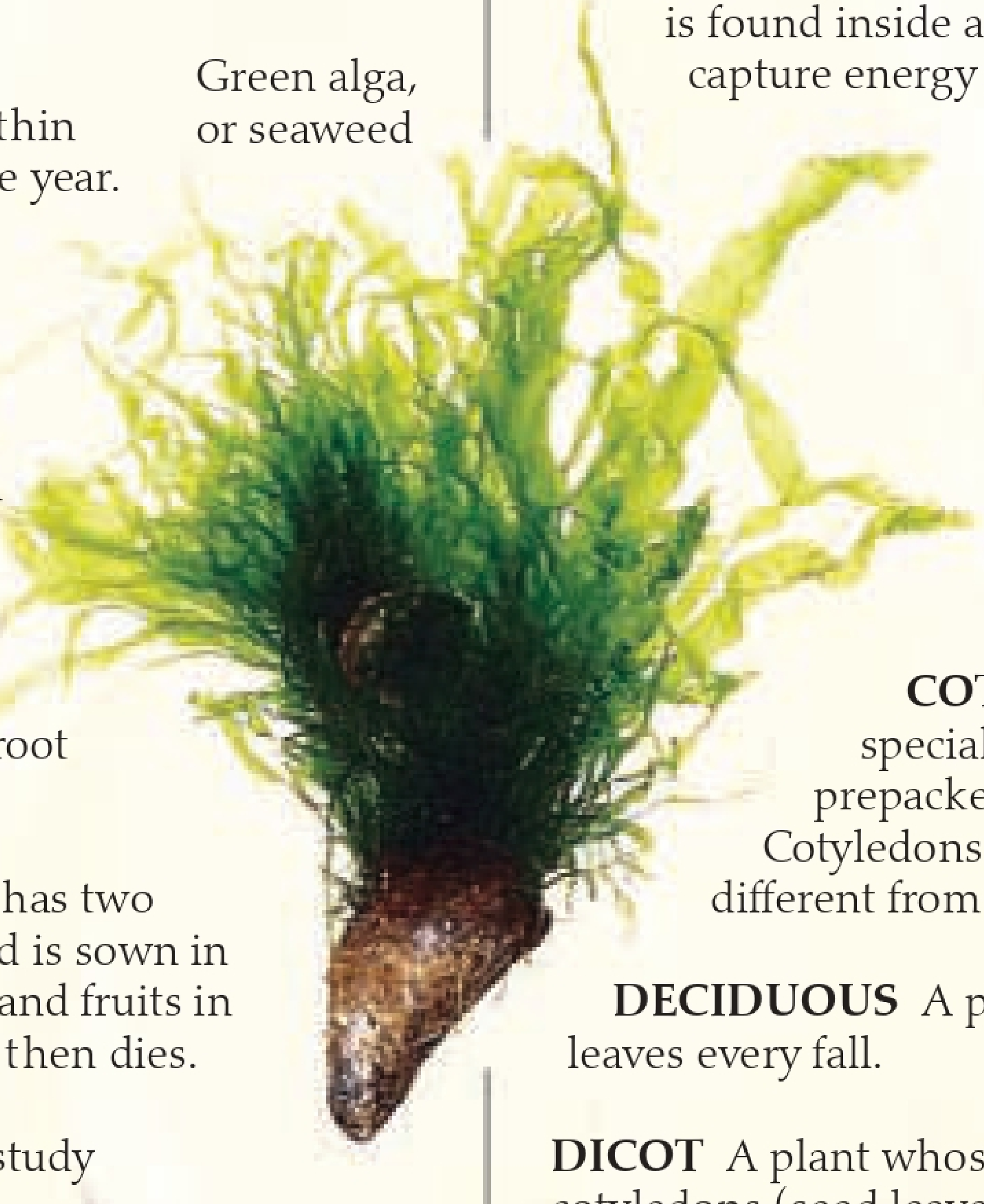
Glossary

ACHENE A dry, one-seeded fruit. All plants in the buttercup family have achenes.

ALGA A simple nonflowering plant that usually lives in water. Algae include seaweeds and many microscopic species.

ANGIOSPERM A flowering plant. Unlike gymnosperms, angiosperms grow their seeds inside a protective case called an ovary, which develops to form a fruit.

ANNUAL A plant that completes its life cycle within the growing season of one year.



Green alga, or seaweed

ANTHER The tip of a flower's stamen containing pollen.

AXIL The angle between the upper part of a stem and a leaf or branch. Buds develop in the axil.

AXIS The main stem or root in a plant.

BIENNIAL A plant that has two growing seasons. The seed is sown in the first year and flowers and fruits in its second year. The plant then dies.

BOTANY The scientific study of plants.

BRACT A small, leaflike flap that grows just beneath a flower.

BUD The first visible sign of a new limb of a plant, or the protective case that encloses a flower that is still growing inside.

BULB An underground stem that stores food inside layers of fleshy scales. Most plants use bulbs to survive drought or cold.

BULBIL A small bud that grows into an independent plant.

BURR The prickly seed case of some plants.

CALYX The ring of sepals that protects a flower bud. The calyx often falls off when the flower blooms.

CARPEL The female organ of a flower. It consists of the stigma, the style, and the ovary.

Stem and leaves sprout from the bulb

Daffodil bulbs

CELL The smallest possible unit of living matter, visible only under a microscope. A cell consists of a nucleus surrounded a fluid called cytoplasm and bounded by a cell wall.

CHLOROPHYLL The green pigment present in all plants and algae and involved in the process of photosynthesis.

CHLOROPLAST A microscopic green structure that contains chlorophyll and which is found inside a plant cell. Chloroplasts capture energy from sunlight.

CLIMBER A plant that grows upward and outward, attaching itself to structures such as walls and fences.

COROLLA The ring of petals in a flower.

COTYLEDON A specialized leaf that is prepacked inside a seed. Cotyledons often look very different from ordinary leaves.

DECIDUOUS A plant that loses its leaves every fall.

DICOT A plant whose seeds have two cotyledons (seed leaves). The leaves of a dicot, or dicotyledon, are often broad, and they have veins arranged in a network.

EMBRYO A young plant in its earliest stages of development.

ENDOSPERM A supply of food that is stored inside a seed. The endosperm fuels the seedling's early growth.

EVERGREEN A plant that retains its leaves all year round, such as pines and firs.

FILAMENT The stalk of a stamen that suports the anther.

FLORET A small flower that forms part of a composite flower, or flower head.

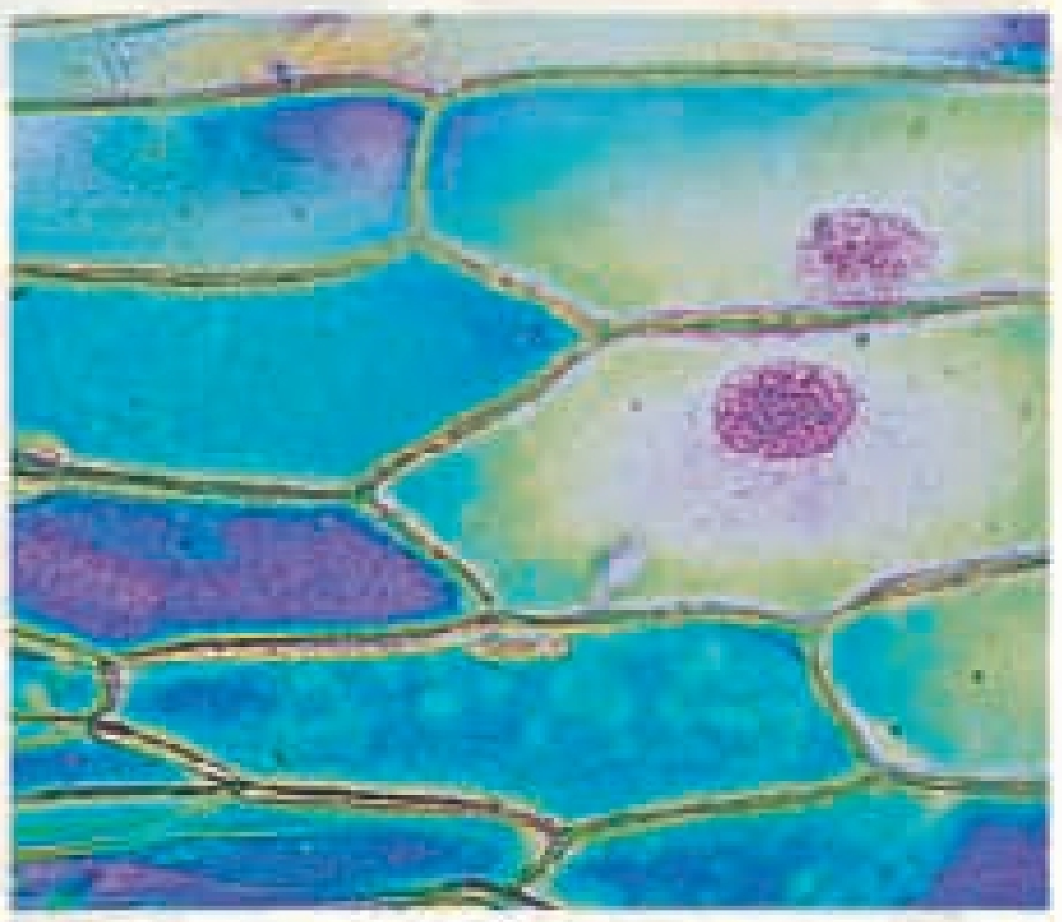
GERMINATION When a seed begins to sprout and grow.

GYMNOSPERM A plant whose seeds do not develop inside an ovary. Most gymnosperms are coniferous trees.

HARDY Being able to withstand extremes of temperature, such as cold and frost.

MONOCOT A plant whose seeds have a single cotyledon (seed leaf). The leaves of a monocot, or monocotyledon, usually have parallel veins.

MULTICELLULAR Made up of more than one cell.



Microscopic view of typical plant cells

NECTAR A naturally occurring sweet liquid found in the glands of many flowers.

OVARY A female reproductive organ that encloses fertilized seeds.

OVULE A collection of female cells that form a seed after they have been fertilized by pollen.

PAPPUS A ring or parachute of very fine hair that grows above a seed and helps it to be dispersed by the wind.

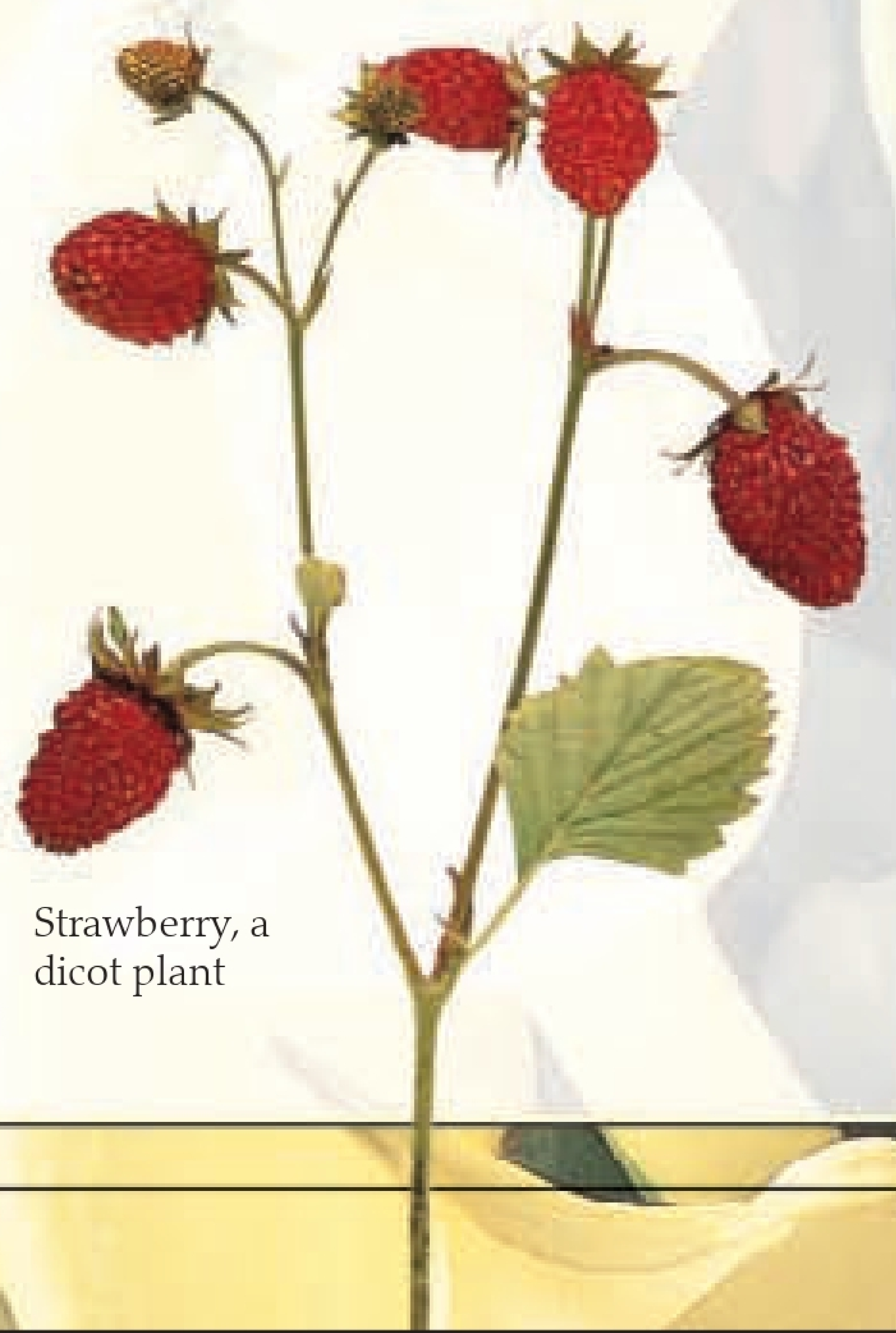
PARACHUTE Any structure that aids the spread of seeds by the wind, such as a pappus.

PARASITE An organism that lives in or on another organism, or host, from which it takes food and energy without giving anything back in return.

PERENNIAL A plant that lasts or flowers for more than two years.

PERIANTH The part of a flower made up of the calyx and the corolla together.

PETAL A leafy flap in a flower, often brightly colored to attract animal pollinators.



Strawberry, a dicot plant

PHLOEM A system of cells that carries nutrients throughout a plant.

PHOTOSYNTHESIS The process by which plants generate their own food, occurring when a green pigment called chlorophyll reacts with sunlight, carbon dioxide, and water to make carbohydrates, water, and oxygen.

PIGMENT A colored chemical used by plants to collect light. One pigment, chlorophyll, makes plants look green.

PLANTLET A young plant, which is sometimes attached to its parent.

PLUMULE The embryo shoot in a seed.

POLLEN Microscopic grains containing male sex cells. Pollen is produced by the anthers of flowers.

POLLINATION The process by which pollen is carried from one flower to another. The male pollen fertilizes the female ovule and creates a seed. Insects and animals often carry pollen between flowering plants, or it can be blown by the wind.

RECEPTACLE The part of a plant that contains the flower, or in flowerless plants, the reproductive organs or spores.

RHIZOME A creeping underground stem. Rhizomes often sprout leaves as they push their way through the ground.

ROOT The part of a plant that anchors it to a solid surface, such as soil, and absorbs water and nutrients.

RUNNER A stem that produces new plants by growing across the ground and sprouting roots.

Bamboo, a monocot plant

Poppy seeds scattered by the wind

SEED A tough structure used by plants to reproduce. A seed contains a young plant, or embryo, together with all the food reserves it needs to start life on its own.

SEPAL A leafy flap that protects a flower while it is still a bud. Sepals often fall off when the flower opens.

SHOOT The parts of a plant above ground, including its stems, leaves, and flowers.

SPADIX A fleshy spike of flowers.

SPATHE A leaflike hood that partly encloses a flowerhead.

SPECIES A group of plants, or other living things, that look similar, and that normally breed together in the wild.

SPORE A single-celled reproductive unit of some organisms.

SPUR A flowering or fruit-bearing branch that shoots out from an existing plant.

STAMEN The pollen-producing part of a flower, consisting of a filament and an anther.

STARCH The main food type stored in a plant. Chemically known as a carbohydrate, this food contains vital energy reserves.

STEM The part of a plant that carries the leaves. Also known as a stalk, the stem transports water and food from the roots to the rest of the plant.

STIGMA The structure in a flower that receives pollen during pollination.

STOMA An opening through which gases enter and leave the green part of a plant.

STYLE The stalklike structure in a flower that connects the stigma with the ovary.

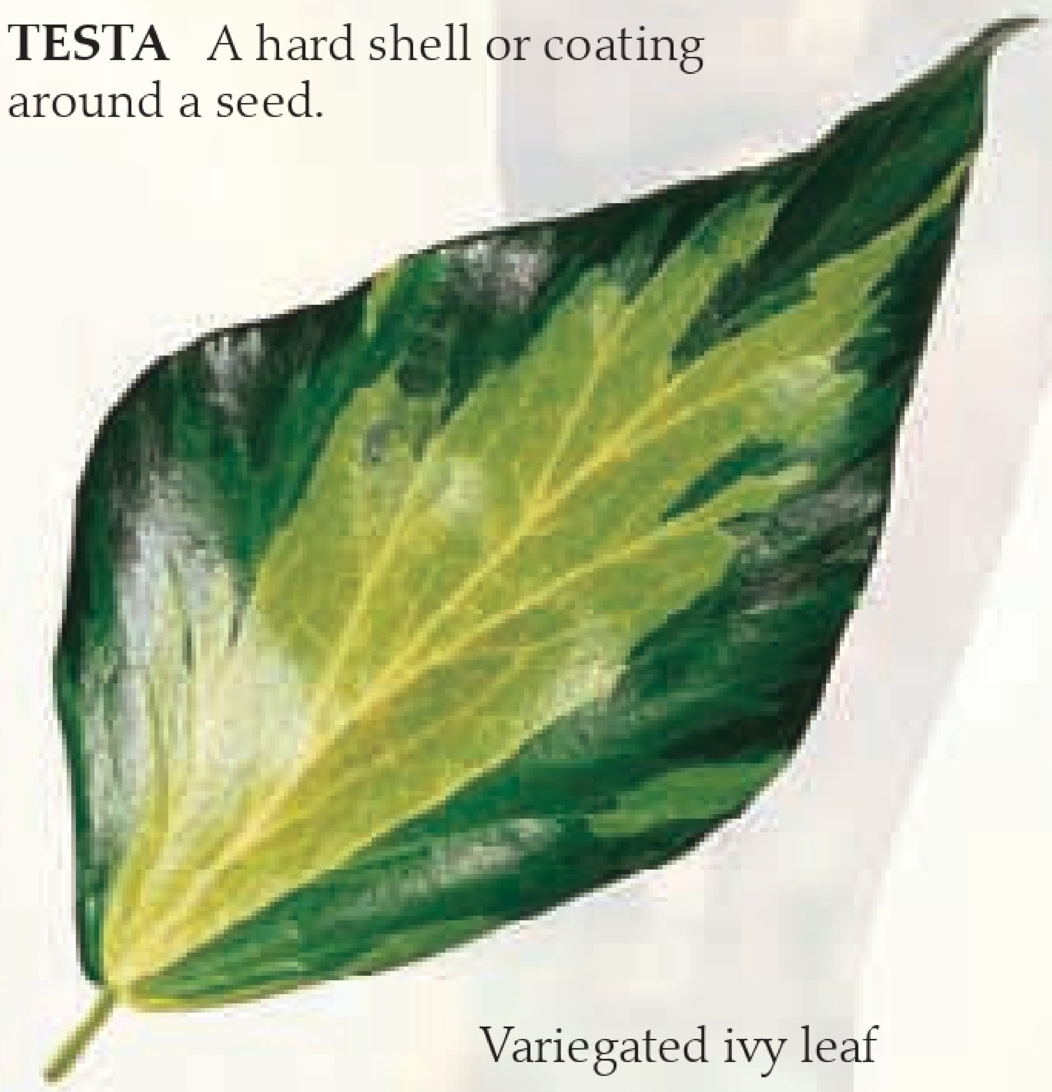
TAPROOT A main root growing down.

TENDER A plant that is sensitive to the cold.

TENDRIL A threadlike part of a plant that grows outward and wraps around nearby objects, helping the plant to stay upright.

TEPAL A flap around a flower that performs the functions of both sepal and petal.

TESTA A hard shell or coating around a seed.



Variegated ivy leaf

TRANSPIRATION The movement of water through a plant. Water is taken up by the roots, and it evaporates through pores in the leaves.

TUBER A swelling or lump that forms in a root or stem and usually contains valuable food reserves for the rest of the plant. A potato is a tuber.

UMBEL An umbrella-shaped flowerhead.

VARIEGATED Streaked or mottled, with contrasting colors. In plants, variegated leaves are caused by differences in the pigments across the leaf.

VEGETATION The plants found in a particular habitat or environment.

WHORL A collection of leaves, sepals, or petals growing in a circle around a plant stem.

XYLEM A system of cells that carries water through a plant. In shrubs and trees, toughened xylem cells form wood.

ZYGOTE A fertilized egg.

Index

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EVOLUTION
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FARM
FILM
FIRST LADIES
FISH
FLAG
FLYING MACHINE
FOOTBALL
FORCE & MOTION
FOSSIL
FUTURE
GORILLA, MONKEY & APE
GOYA
HORSE
HUMAN BODY
HURRICANE & TORNADO
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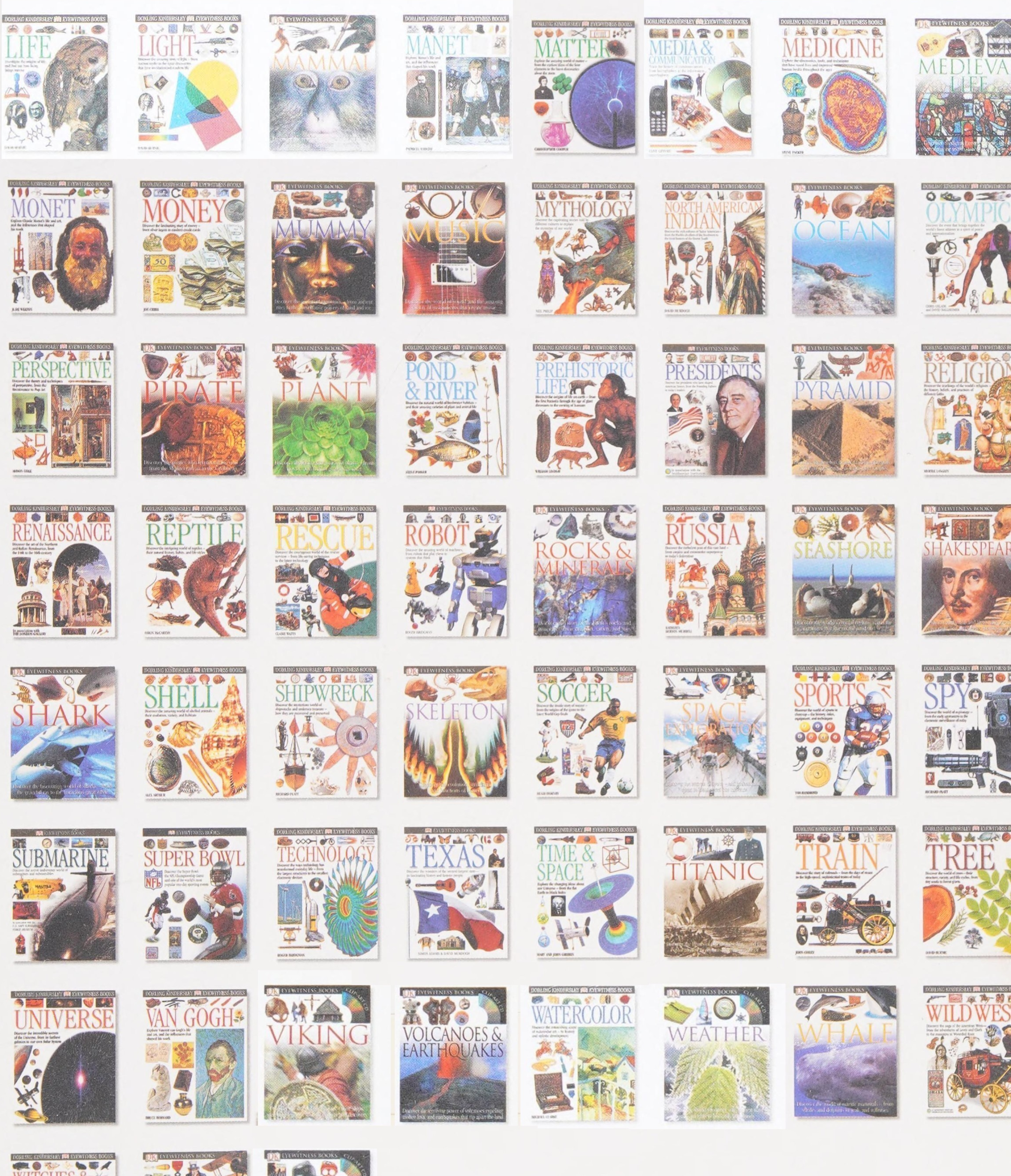

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